New Frontiers

Technology Development and Applied Research in Alberta

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MESSAGE FROM THE PREMIER

The application of research and development results to promote growth and diversification of Alberta's economy has long been important in our province. In 1921, Alberta created the first provincial research organization in Canada and the province still continues to devote substantial resources to technology development and applied research.

"New Frontiers: Technology Development and Applied Research in Alberta" describes some of these accomplishments and activities in agriculture, energy, environment, medicine and high technology. It also describes how the private sector, the universities and the provincial and federal governments work together to achieve common goals.

Alberta's active technological development and applied research community has a proven record for successful commercialization of research results. I take great pleasure in introducing you to this overview which reflects this government's commitment to Alberta's leading position at the forefront of new technology.

Don R. Getty

December 2, 1985

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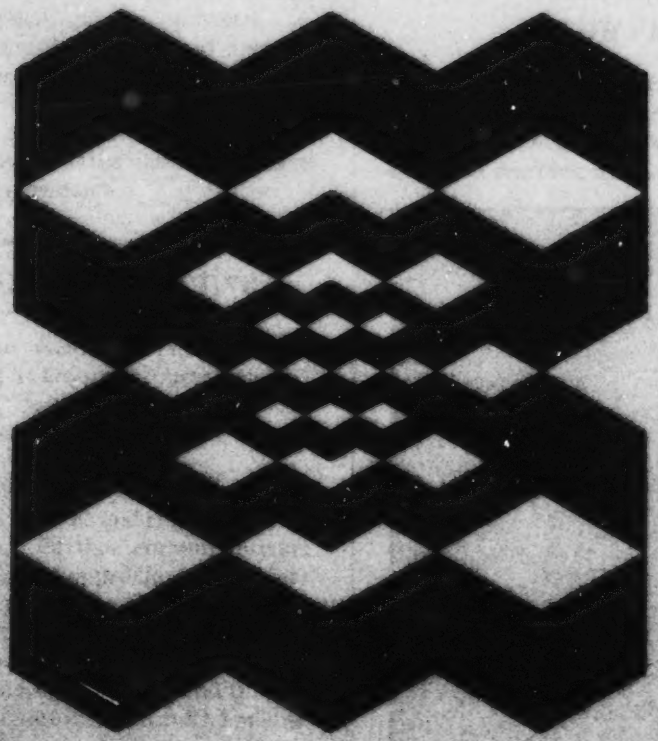
Introduction



Introduction

In today's fast-paced, technologically- oriented world, scientific research and development have become fundamental to economic prosperity and a higher quality of life.

The Province of Alberta has taken a particularly active role in encouraging scientific research and development, not only within its boundaries, but across Canada and elsewhere in the world as well.

This publication gives a brief overview of the research and development network in Alberta and how it is supported through the cooperation of industry, the scientific and educational community, and government.

Examples of private and public sector research efforts are presented in such key areas as energy, agriculture, forestry, environment, medicine and forefront technologies. These efforts encompass work at all research levels: basic, applied, and developmental.

The list of research areas, projects, and agencies presented is by no means exhaustive. Examples were chosen to demonstrate the quality of research and development in Alberta and the calibre of the people who are choosing this province as the right environment for creative and productive research.

The Canadian Perspective

Alberta's commitment to research and development is a natural outgrowth of its unique resource base and its individual sense of destiny. These have been bolstered by strong national encouragement of research activities.

Total 1984 research and development expenditures in Canada in the natural sciences and engineering are estimated at $4.9 billion. Of that amount, private sector funding accounts for approximately 42 per cent, federal government funding for 38 per cent, universities for 6 per cent, provincial governments for 6 per cent and other sources, 7 per cent (Figure 1). Industrial research and development expenditures in Canada for the same year are estimated at $2.5 billion, up five per cent from 1983.

While it ranks fourth among Canadian provinces in population, Alberta ranks third in the amount of industrial research undertaken in its jurisdiction.

Total expenditures by the Province of Alberta on research and development in the natural sciences have increased from 1977/78 to 1984/85 on the average of 21 per cent per year (Figure 2). On a per capita basis, total Alberta government funding of research and development in the natural resources is approximately three times that of any other provincial government (Figure 3).

Since 1981/82, the aggregate annual expenditure by all sectors in Alberta on research and development in the natural sciences has exceeded $450 million. The 1983/84 figure of $458 million represents approximately 9 per cent of all research and development expenditures in Canada.

The Alberta Advantage

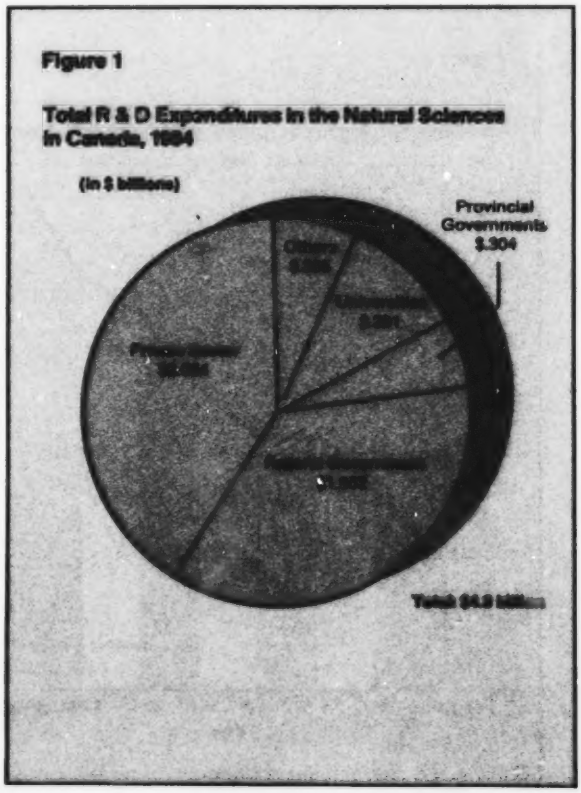
Resources, Opportunity and Commitment

THE PROVINCE

Alberta enjoys the advantage of vast reserves of natural resources within its boundaries. These include more than 690 million cubic metres of conventional crude oil reserves; about 1.8 trillion cubic metres of

Figure 1

Total R & D Expenditures in the Natural Sciences in Canada, 1984



natural gas; over 160 billion cubic metres of recoverable oil sands (the largest known deposit in the world); more than 40 billion tonnes of high quality coal; forests containing 1.7 billion cubic metres of wood; 20 million hectares of productive agricultural land; a potential annual source of 60,000 gigawatts (60,000 billion watts) of electricity; plus extensive deposits of non-metallic and metallic minerals.

Alberta's location and resource base have contributed to its growth as a major Canadian transportation, business and service hub.

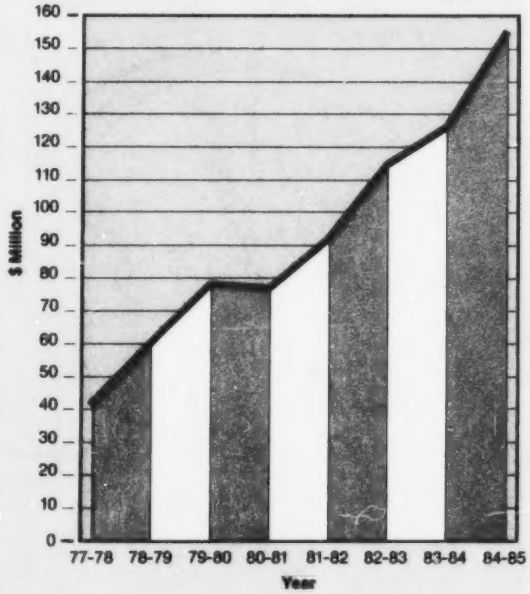
THE PEOPLE

More than 2.3 million people live in Alberta. The province's two largest cities — Edmonton, the capital, and Calgary — each has a population of more than one half million.

Alberta's population is best described as youthful, dynamic, and culturally and ethnically diverse. Albertans are well-educated, enjoying the benefits of a province-wide network of public and private primary, secondary and post-secondary educational institutions. Edmonton, Calgary and Lethbridge are each home to a university. A fourth university, Athabasca, provides post-secondary distance education. Numerous community colleges and technical institutes are located throughout the province.

Figure 2

Alberta Government Expenditures for Research and Development in the Natural Sciences, 1977-1984.



THE ECONOMY

An abundance of natural resources and low-cost energy, the lowest overall taxation rates in Canada, and a political climate supportive of the free enterprise philosophy combine to make Alberta a province of opportunity.

For the past decade, the petroleum industry has been the most vital sector in the province's economy, spurring the growth of service and processing industries and providing the income necessary for diversification of the industrial base.

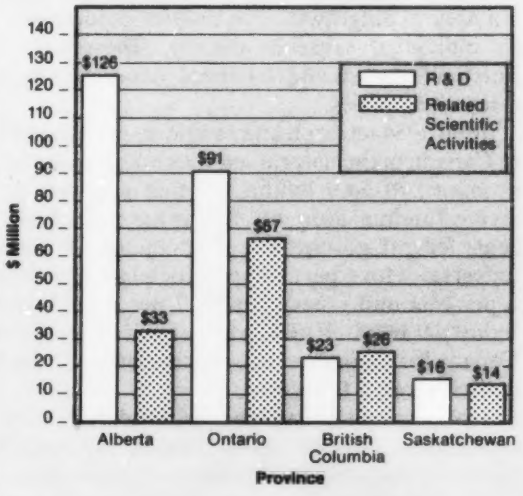
Agriculture is Alberta's second largest industry. The province accounts for about 20 per cent of Canada's agricultural output. Alberta also has significant manufacturing, construction, tourist, forestry and electric power industries and is home to a rapidly-growing number of companies involved in a wide range of intensive technology products, services and processes.

THE COMMITMENT

To diversify its industrial base and make the best use of its human and natural resources, the Government of Alberta has actively encouraged the development of the province's scientific, industrial and tech-

Figure 3

Provincial Government Expenditures for Scientific Activities in the Natural Sciences, 1984.



nological capabilities.

In 1984, the publication of a government White Paper led to discussion and formulation of a provincial industrial and science strategy for 1985 to 1990. The White Paper outlined areas of current and possible future research and development, stressing ". . . it is essential that Alberta maintain a healthy program of scientific and engineering research, to be subsequently developed into technology and directed to enhance the province's economic and social development and improve the quality of life."

A strong commitment to research and development in Alberta also comes from educators, scientists and industry. This commitment has led such corporations as Bell Northern Research, Esso Resources, Shell Canada Resources, Sherritt Gordon Mines and Dow Chemical to locate major Canadian research operations in Alberta.

The Alberta Research Network

Alberta's research network comprises many corporations, institutions and private and public agencies, as well as an impressive array of laboratory, testing and service facilities.

The following is a brief summary of some of the major players within that network.

INDUSTRY

Private industry makes up the largest component of Alberta's research network, performing 38 per cent of all research and development in the province in 1983/84, and 25 per cent of all provincial government funded research and development in the natural sciences during that year.

While the majority of industrial research in Alberta is related to the petroleum industry, the province annually attracts a number of new companies interested in developing other opportunities.

Due to this constantly changing situation, it is not feasible here to mention all the companies or institutions contributing to research and development in Alberta. Instead, some examples have been chosen to illustrate areas where Alberta has developed a particularly advantageous environment for industrial partners. These are presented in appropriate sections elsewhere in this publication.

UNIVERSITIES

Alberta's three major universities supply skilled graduates in all areas of science, and work closely with industry and government on basic and applied research and development problems.

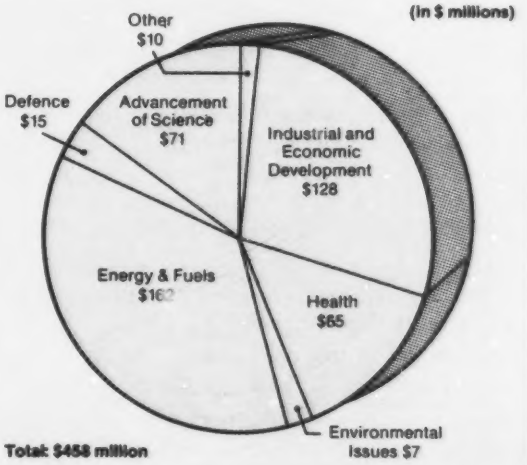
Together, the three universities received research grants and contracts amounting to approximately $84 million in 1983/84. These include grants from and contracts with the Alberta Oil Sands Technology and Research Authority (AOSTRA) to generate new or improved technology and to train individuals to assist in developing Alberta's heavy oil and tar sand resources. Not included is that portion of the province's operating grant to universities which is devoted to research. Assuming that two-thirds of an institution's activity is devoted to teaching and one-third to research, expenditures on university research were substantially more than double the value of the $84 million grant and contract figure for the year, and amounted to $179 million.

University of Alberta. The University of Alberta in Edmonton is the province's oldest and largest research performing institution. It received approximately $47 million in research grants and contracts in 1984.

With strong Faculties of Medicine, Agriculture and Forestry, Engineering, Science, and Pharmacy, the University gears its industrial laboratory research toward Alberta's current economic base in agriculture and oil and gas; to resource areas of future significance in forestry and coal; to new

Figure 4

Application of Research and Development Expenditures in the Natural Sciences and Engineering in Alberta, 1983-84



product development in fields such as pharmaceuticals and engineering design technology; and to the application of new technology in existing industrial systems through microelectronics and other areas on the leading edge of international developments. A diverse range of state-of-the-art research projects in basic sciences puts the University, its staff and facilities, at the frontiers of fundamental research.

University of Calgary. The University of Calgary received external research grants and contracts for 1983/84 totalling $31 million.

The Faculties of Medicine, Engineering and Science account for most of the grants and contracts, and encompass nine major medical research groups in areas ranging from genetic engineering to cell regulation and behavioral sciences. There are leading programs in survey, chemical and petroleum, civil and electrical engineering. Research in the sciences includes basic research in chemistry and biotechnology with applications to agriculture and forestry, and participation in major environmental projects. Petroleum related research includes an institute of sulphur chemistry, investigations of oil sands bitumen, basic studies of geological phenomena related to enhanced oil recovery, and a large-scale geophysical (seismic) project. Emerging research strengths at the University are related to intensive computer software development, a VLSI design facility, mathematical interpolation methods for representation of digital data, and satellite imaging techniques associated with atmospheric and space physics programs.

University of Lethbridge. The University of Lethbridge received approximately $1.3 million in research grants and contracts in 1983/84.

Research at the University includes individual projects on the environmental effects of oil sands plants, the development processes in poplar and maize, animal parasites in water systems in the province, aspects of neuropsychology and perceptual problems in infants.

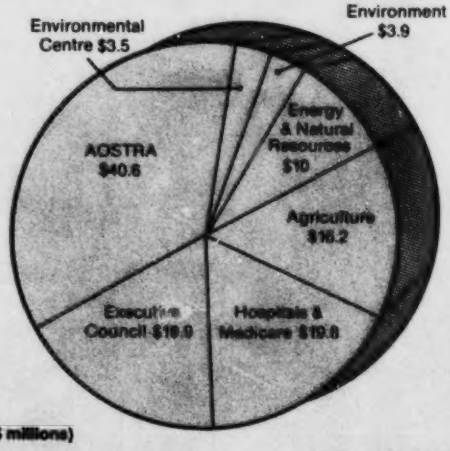
PROVINCIAL GOVERNMENT DEPARTMENTS AND AGENCIES

The Government of Alberta is the largest single source of funding for research and development in the province.

In 1983/84, $458 million was spent on research and development in the natural sciences by all sectors and agencies in Alberta. These funds were applied in the following areas: advancement of science, $71 million; defence, $15 million; energy and fuels, $162 million; environmental issues, $7 million; health, $65 million;

Figure 5

Major Provincial Funding Departments or Agencies for R & D in the Natural Sciences in Alberta, 1983-84*



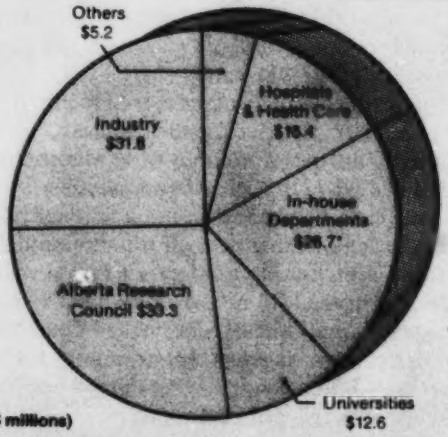
(in $ millions)

*Current expenditures for R & D only

Total: $113.9 million

Figure 6

Key Performers of Alberta Government Funded Research & Development in the Natural Scences, 1983-84.



(in $ millions)

*Figure includes $11.4 million in capital expenditures.

industrial and economic development, $128 million; and other, $10 million (Figure 4).

Research and development expenditures of the Government of Alberta in the natural sciences totalled $126 million in 1983/84. The major provincial funding departments or agencies were the Alberta Oil Sands Technology and Research Authority ($40.6 million); the Executive Council ($19.9 million); the Departments of Hospitals and Medical Care ($19.8 million), Agriculture ($16.2 million), Energy and Natural Resources ($10 million), Environment ($3.9 million); the Environmental Centre ($3.5 million) (Figure 5).

The key performers of government-funded research in the natural sciences were industry ($31.8 million); Alberta Research Council ($33.3 million); in-house government departments or agencies ($26.7 million); hospitals and health organizations ($16.4 million); universities ($12.6 million); and others ($5.2 million) (Figure 6).

Individual provincial government research agencies or funding bodies will be mentioned in the relevant sections. Some that merit special note are:

The Alberta Environmental Centre (AEC). The Centre was opened in 1981 in Vegreville. About $50 million has been invested in the Centre, which has a staff of 250 and an annual budget of over $13 million. It is Canada's first interdepartmental, interdisciplinary environmental research and service agency.

Alberta Heritage Foundation For Medical Research (AHFMR). The AHFMR was created in 1979 to establish and support a balanced long-term program of medical research based in Alberta. The main activity of the Foundation, which uses the interest revenue generated from a $300-million endowment from Alberta Heritage Savings Trust Fund, is an awards and grants program supporting researchers in the basic medical and clinical sciences, as well as in a broad spectrum of medically related disciplines. By the end of March 1984, the Foundation had contributed $67 million directly to the work of the scientific community. In 1985, construction was commenced on two clinical research laboratories, located in Calgary and Edmonton, at a cost of around $30 million each using AHFMR funds.

The Alberta Oil Sands Technology and Research Authority (AOSTRA). Established in 1975, AOSTRA is funded through the Alberta Heritage Savings Trust Fund and provides financial incentives to the private sector and research institutions to develop economically viable and environmentally acceptable petroleum technology in areas related to oil sands, heavy oil and enhanced recovery of conventional oil.

By the end of 1985, the Authority had committed more than $400 million to research projects, primarily field projects with industry that are handled on a shared cost or cost recovery basis. AOSTRA/industry developed technology has led to commercial ventures in Peace River and Cold Lake deposits recently announced by Shell and BP.

Alberta Research Council (ARC). Formed in 1921, ARC is the oldest provincial research organization in Canada. It is also the largest, with over 500 employees (including 230 professional scientists and engineers) and an annual budget of $38 million, of which $34.6 million is derived from Executive Council and other provincial government departments and agencies, and the remainder by contracts from the private sector and the federal government.

ARC has developed seven major programs — oil sands, energy processing, natural resources, biotechnology, industrial technology, service to industry, and advanced technologies.

Farming for the Future. An agricultural research program financed through the Alberta Heritage Savings Trust Fund, Farming for the Future was established to support the advancement of agricultural technology by augmenting and complementing research efforts by private industry, universities and government agencies.

By the end of 1984/85, $28 million had been allocated through this program to support over 200 research projects.

The Government of Alberta also has participated in several economic initiatives which, under appropriate circumstances, may provide financial assistance to research and development ventures. These include:

Vencap Equities Alberta Ltd. Backed by a $200-million loan from the Alberta Heritage Savings Trust Fund and by a debenture and common share offering to the public, Vencap provides equity-linked financing to entrepreneurs to develop high risk or innovative businesses.

Alta-Can Telecom Inc. A wholly-owned subsidiary of Alberta Government Telephones, this company assists fast-growth new areas of microelectronics and telecommunications with risk capital, joint venture investments and technological expertise.

Joint Venture Program. Alberta Research Council initiated this program to undertake research with companies on an equally-shared joint venture basis. Council participation may be to a maximum of $500,000 annually per firm for five years.

Product Development Program. This program of Alberta Economic Development provides front-end financial support to Alberta businesses for improving their products.

As part of its commitment to research and science, the Government of Alberta is also involved in the sharing

of expertise and joint venture projects with other national and international jurisdictions. This interaction includes Farming for the Future and AOSTRA funding of research activities in other areas of Canada, as well as involvement of several government agencies with agencies of the United Nations and of countries including Japan, China, South Korea, Venezuela, the United States, the Malagasy Republic and Turkey. Alberta also has an "open door policy" of scientific exchange with Western European countries, Australia and New Zealand.

Alberta has worked particularly closely with Canada's federal government on a number of joint research activities, not only in agriculture, but also through such programs and agencies as the Industrial Research Assistance Program, the Alberta/Canada Energy Resources Research Fund, the Alberta Oil Sands Environmental Research Program and the Sulphur Development Institute of Canada.

FEDERAL GOVERNMENT DEPARTMENTS AND AGENCIES

The Canadian government is a major funder of research and development in Alberta, through its research establishments in the province and through the nation-wide programs of its scientific agencies.

Of the federal government's expenditure on research and development in Alberta in 1983/84, $56 million was spent in federal natural science establishments located in Alberta and operated by the Departments of Agriculture; Environment; Energy, Mines and Resources; and National Defence.

A substantial amount of federal funding and expertise is contributed each year to industry, universities and other agencies in Alberta through major federal government agencies, including:

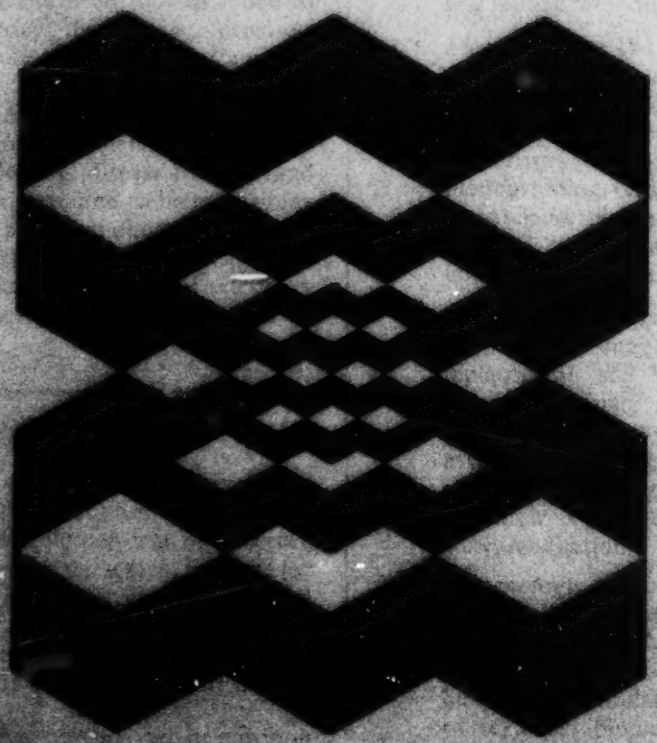
National Research Council of Canada (NRC). The principal research agency for the federal government, the NRC provides direct financial and advisory assistance to industry.

Natural Sciences and Engineering Research Council of Canada (NSERC). NSERC funds research in the natural sciences and engineering, excluding health sciences. The Council's funding is directed towards universities.

Medical Research Council of Canada (MRC). The MRC provides grants to help defray the costs of basic, applied, experimental, or clinical research; provides salary support to a limited number of investigators and research trainees in Canadian universities; and sponsors programs to help develop research in fields where major contributions may be expected.

A number of federal financial assistance programs benefit companies engaged in research and development in Alberta. Information on such programs may be obtained through Canadian government offices.

Agriculture and Forestry



Agriculture and Forestry

Alberta has an abundance of fertile agricultural land and productive forests, and the technological expertise to make the best use of those valuable resources.

Nearly 49 million acres of land in Alberta are used in crop and livestock production. Another 150,000 square miles, comprising 60 per cent of the province, are covered by forests.

The need to manage these resources effectively has spawned a number of research and development efforts by industry, universities and government.

Agriculture

Agriculture has historically been the backbone of Alberta's economy. Today, the province produces about 20 per cent of the total value of Canadian agricultural output.

Research in the province has provided solutions to a broad range of agricultural problems, leading to the development of high-yielding, disease resistant and early maturing crop varieties, and to better farming techniques, equipment, pesticides and fertilizers. The development of new technology in such areas as genetic engineering, animal nutrition, and veterinary medicine has placed Alberta's livestock industry at the forefront.

UNIVERSITIES

The University of Alberta. The University of Alberta's Faculty of Agriculture and Forestry accounts for more than 90 per cent of Alberta's university-based agricultural research. Funding for this research involves interaction with industry and government.

About three-quarters of the Faculty's research resources are concentrated in the following areas.

Animal Science. Research areas include nutrition and production of beef and dairy cattle, pigs and poultry; breeding of beef cattle; nutrition of horses; management and production of wildlife; and basic cross species studies in genetics, biochemistry, physiology and growth. The University operates a number of facilities where both applied and basic research are conducted, including an experimental farm at Ellerslie which focuses on beef cattle nutrition studies, and an experimental ranch at Kinsella, where beef cattle genetics and management studies produce research that is often directly transferable to producers.

Food Science. In addition to extensive research in microbiology, chemistry and engineering/processing, this department operates a pilot plant on campus which represents units present in the food industry — from freeze drying to vacuum packaging — and offers an environment for research with industry applications. The Alberta Dairymen's Research Unit is located in the Department, and inspection testing as well as research involving product evaluation and handling is done for industry.

Plant Science. The Plant Science Department operates off-campus facilities at the Parkland and Ellerslie Research Stations, where much of the fieldwork in support of its research is carried out. Areas of research include horticulture; plant breeding; range and pasture management; weed science; plant pathology; and plant physiology and biochemistry. Greenhouses are maintained by the Department on campus.

Soil Science. Projects — from basic science to applied technology — include soil fertility and replacement; soil biology and biochemistry; nutrient dynamics; mineralogy and micromorphology; soil management; and remote sensing as it applies to land evaluation. Major research is carried out on the gray wooded soils at Breton. Research is also conducted at the Ellerslie Research Station.

Entomology. The Entomology Department concerns itself with a broad spectrum of problems in insect biology. Current research programs include studies on feeding behavior of blackfly larvae and phytophagous beetles, genetic control of tsetse flies, bionomics of various pest insects, mode of action of feeding deterrents, taxonomic studies on various beneficial insect groups, developmental processes in thrips and bugs, and habitat location in ground beetles.

Agricultural Engineering. Agricultural Engineering is involved in research dealing with the efficient use of farm machinery, instrumentation, irrigation and drainage, and environmental con-

trol in farm structures. Off-campus facilities are maintained at the Ellerslie and Parkland Research stations.

Rural Economy. Research in the Department of Rural Economy includes activities touching on the farm, the processing sector and on wider issues in agriculture and forestry. Farm and industry studies include continuous cropping, crop selection, assembly/efficiency in livestock marketing, cost implications of grain grading, barriers to technical change in food processing, economic ranking of methods to improve grazing lands, as well as a project in which farmer-researcher cooperation seeks to identify and research farm problems, from risk management to acceptance of new technology, to desirability of new tax systems. Studies have been or are being done on public issues such as pricing efficiency in canola, multiple land use, forest and sawmill related economics, benefits and costs of irrigation, and approaches to farm land preservation. In addition, studies on policy issues have focused on quota values in marketing, sources of agricultural productivity, effects of rail rate changes on Alberta farmers, and issues in agricultural development, agricultural extension and agricultural trade.

The University of Calgary. While the University of Calgary does not have an agriculture faculty, research related to agriculture is conducted by other faculties. The Biology Department operates greenhouses and environmentally controlled plant growth chambers. Research projects in plant biology include work on seed development, dormancy and germination; plant physiology; and plant propagation. Crop plant tolerance to drought, salinity, flooding, control of rooting characteristics, and studies of orchids are among the projects in Biology of an agricultural nature. Other projects are conducted in cellular, microbial and environmental biology.

The University of Lethbridge. The University of Lethbridge also does not have an agriculture faculty. Agriculture related research is conducted in the Biology Department, where projects include work on poplar, maize and plant physiology.

Colleges. Advanced development, testing and demonstration facilities are available at or through a number of agricultural colleges in the province. These include Olds College, Fairview College, Vermilion College, and Lethbridge Community College.

Research is conducted at these institutions in numerous areas, including horticulture, floriculture, crop and livestock management, apiculture, plant growth regulators, forages and irrigation technology.

OTHER RESEARCH CENTRES

To ensure efficient utilization of research personnel and funding, the Alberta government has made substantial investments in a number of facilities located or headquartered in Saskatchewan. These facilities provide training in necessary agricultural and agriculture-related professions — such as veterinary medicine — or act as sources of new technology for agriculture in Alberta.

Among these institutions are the Western College of Veterinary Medicine (WCVM) and the related Veterinary Infectious Disease Organization (VIDO), both of which are located at the University of Saskatchewan in Saskatoon, Saskatchewan. Alberta provided the greater part of the capital funding needed to develop VIDO, and its support for VIDO continues today in the form of various types of operating money. The Farming for the Future program alone contributes more than $500,000 per year to the WCVM and to VIDO to support genetic and management research related to ruminant and non-ruminant animals and poultry.

The Prairie Agricultural Machinery Institute (PAMI) maintains facilities in Manitoba, Saskatchewan and Alberta which test new machinery for both local and prairie-wide applications. Alberta's PAMI facility, located in Lethbridge, also conducts important evaluating and testing procedures on machinery developed and manufactured in Alberta.

THE GOVERNMENT OF ALBERTA

The Government of Alberta has considerably expanded its involvement in agricultural research in recent years. The main thrust is to support research programs which have the potential to improve net farm income, increase value-added processing, and enhance the long-term viability of agriculture in Alberta.

In the fiscal year 1984/85, Alberta Agriculture's expenditure on research and development, both through special funding programs and through departmental activities, was approximately $20 million. The Department's research funding programs include: Farming for the Future, the Weather Modification Project, and the Alberta Agricultural Research Trust. A central research fund is also maintained for internal projects not covered under divisional budgets.

The major research and technology related services of Alberta Agriculture are delivered through Farming for the Future and through line divisions that operate the Department's internal research facilities.

Farming for the Future. Administered by the Agricultural Research Council of Alberta, Farming for the Future has two funding programs: the Research Program and the On-Farm Demonstration Program. By the end of the 1984/85 fiscal year, financial support had been allocated for 373 Research projects and 175 On-Farm Demonstration projects.

To date, more than 200 scientists have participated in this program, providing Alberta agricultural producers with direct access to the expertise of agricultural scientists from across Canada. Projects are being conducted at federal and provincial government agencies, academic institutions and private industry laboratories, as well as various farm sites across Alberta. The following are examples of areas of research supported:

Cereals and Oilseeds. The major objective here has been to extend financial support to projects aimed at improving the productivity and efficiency of Alberta's cereal and oilseed sector. Topics of study include breeding higher-yielding, disease resistant and early maturing cereal and oilseed crops, regional variety testing, and improved methods of crop production.

Crop Protection and Entomology. Funds have been awarded for projects focusing on crop protection from insect pests, weeds and plant diseases. Topics of study range from refining methods for controlling insect populations to the management of weeds and crop diseases. Areas of study have also included bee breeding and hive management in support of the province's quest for a self-supporting honey industry.

Forages. Projects in this area have focused on the overall improvement of forage crops. Topics of study have related to forage variety improvement, brush control, varietal testing, and harvesting and storage techniques.

Irrigation. Financial support is provided to projects aimed at increasing water use efficiency and improving drainage to reduce damage from saline seepage. Projects have included testing new canal lining materials, methods of upgrading drainage standards, mapping lands affected by salinity, and evaluating the economic viability of using wind turbines to pump irrigation water.

Land Resources and Engineering. The overall objective in this area is to support projects aimed at conserving and enhancing the productivity of Alberta's farmland. Support is also provided to projects dealing with the design, development and improvement of farm equipment. Specific projects have dealt with conservation of soil nutrients, optimization of production on gray wooded soils, snow management for moisture conservation, crop utilization of nitrogen, evaluation and development of furrow openers for seed and fertilizer placement under no-till conditions, evaluation of zero and minimum tillage under various Alberta soil conditions, and erosion control.

Non-Ruminants. The bulk of the funds allocated to this area have been devoted to research on swine and poultry. Subjects of inquiry include factors which affect the productivity of swine, poultry, horses and rabbits. Emphasis has been placed on the efficient use of feed and feed supplements, better disease control and greater use of domestic sources of high protein feed.

Processing, Transportation, Marketing and Socio-Economics. A wide range of projects is supported in this area. In general, projects focus on technological advancements in the processing, marketing and related components of the agricultural industry. Topics of study range from nutritional aspects of canola oils, and the evaluation of beef quality, to the use of microcomputers for farm financial management. Studies are also funded that emphasize the socio-economic needs of rural Albertans.

Ruminants. The production of ruminant animals (beef and dairy cattle, and sheep) represents a very important sector of Alberta's agricultural industry. Research in this area is aimed at improving the productivity and efficiency of this vital sector. Projects supported have included cattle breeding, embryo transplants, animal nutrition, disease control, cattle adaptability to cold climates, and the management of ruminant animals. More specific investigations have dealt with ways of reducing the incidence of calf scours, including the development and testing of commercial vaccines.

Special Crops. Farming for the Future has helped to promote the production of special crops such as soybeans, safflower, sunflower, pulses and greenhouse products by supporting research aimed at developing improved varieties adapted to Alberta conditions and by investigating methods of disease control. Projects in this area have also included potato cultivator evaluation, in vitro production of saskatoons, sugar beet handling, and regional testing of special crops.

Departmental Research and Facilities. In addition to working closely with Agriculture Canada and university staff, Alberta Agriculture assists in the transfer of technology to producers through extension field staff.

The Department's in-house research facilities include:

Food Processing Development Centre. Financed by the Alberta Heritage Savings Trust Fund, this new facility in Leduc is available to food processors who use Alberta products and want to develop new processes or products or to improve existing ones.

The Centre includes an extension section for problem solving, and a pilot plant section to develop processes on a commercial scale.

Alberta Horticultural Research Center. Located in Brooks, this centre conducts research for southern Alberta and participates in research for other parts of the province in all aspects of crop production: vegetables; field and special crops; bush and tree fruits; flowers; greenhouse crops; and ornamental and shelterbelt trees.

Regional Crops Laboratories. These laboratories, located at Brooks, Fairview and Olds, provide diagnostic and extension services in plant diseases, insects and weeds. The Olds lab is also involved in Alberta's seed potato improvement program. Applied research in the crop protection disciplines is carried out at the Alberta Horticultural Research Center in Brooks and at the Alberta Environmental Centre in Vegreville. The latter provides backup to the Regional Crops Laboratories, serves as the diagnostic lab for its region, and handles the herbicide damage investigations for all of Alberta.

O.S. Longman Building. Laboratories at this Edmonton facility are engaged in soil and feed testing; backup to fish and wildlife field services; animal toxicology; analytical and consulting services to food processors and exporters; food quality, safety, nutritional and sanitation matters; veterinary pathology and microbiology; meat inspection; and milk testing.

Other Facilities and Programs. Alberta Agriculture carries out research in Lethbridge into irrigation systems, water use efficiency and other aspects of irrigation management, and is involved in weather modification research in cooperation with the Alberta Research Council.

The Department operates the Field Crops Branch at Lacombe and veterinary laboratories at Airdrie, Edmonton, Fairview and Lethbridge.

The Department also participates in cooperative research with producers.

Alberta Research Council. ARC's weather modification project uses a new research aircraft which the Research Council developed with INTERA Technologies Ltd. of Calgary to gather information on ice particle formation and the effects of cloud seeding to reduce the growth of hail and increase rainfall. The aim is to reduce agricultural losses due to hail and to gather weather information for agriculturalists.

Biotechnology research conducted by ARC involves the mechanisms of cold tolerance; development of cold and frost tolerant nitrogen-fixing bacteria which are compatible with alfalfa, an important forage crop; and study of bacteria which lead to freezing of such crops as rapeseed and beans under frost conditions.

ARC has a Terrain Sciences Department and has contributed significantly to the soil survey program in Alberta. Research also includes reclamation and land use, especially in northern and central Alberta.

THE FEDERAL GOVERNMENT

Traditionally, agricultural research has been a federal government responsibility. Although the Province of Alberta plays an increasing role in this area, Agriculture Canada is still the single largest agricultural research presence in the province, committing between $15 million and $20 million annually to this effort and operating major research stations at:

Lethbridge. This facility is the largest federal agricultural research station in Canada. Major areas of research include apiculture/entomology; cereals and oilseeds; irrigation, land use and soils; and ruminants. Research on forage crops, non-ruminants, processing, marketing, transportation and special crops is also conducted.

Lacombe. Research here focuses on crops, swine and livestock fertility, with major efforts in cereals and oilseeds; ruminants; non-ruminants; and processing, marketing and transportation. Research into forage crops, land use and special crops is also conducted. The station also houses a meat research centre.

Beaverlodge. Primarily concerned with crop and land management in northern Alberta, this facility concentrates on forage crops, cereals and oilseeds. Work is also carried out on special crops, apiculture/entomoloty, and land use and soils.

Agriculture Canada also operates research sub-stations at other locations. At Fort Vermilion the focus is on crop and land management in northern Alberta; at Vegreville, on solonetzic soils; and at Manyberries, on beef and range management.

The Soil Survey Unit of Agriculture Canada is located in Edmonton and conducts soil surveys in southern and central Alberta. Along with other members of the Alberta Institute of Pedology, the

Unit has been responsible for publication of soil survey reports throughout the province.

INDUSTRY

Alberta offers potential for industrial development in a number of agricultural areas. Examples of private sector companies conducting agricultural research include:

Alberta Livestock Transplants Ltd. The first company in the world to specialize in embryo transfer, Alberta Livestock Transplants of Calgary has become an international leader in embryo transplant technology and bovine genetics through a research and development effort which costs several million dollars annually.

A pioneer in the development of non-surgical transfer methods and in collection of embryos, the company has worked closely with genetics researchers at the University of Calgary Faculty of Medicine, and with the federal and provincial governments. Current research, conducted under contract with the federal government, involves embryo freezing and micro-manipulation of the embryo to produce genetically identical twins.

Work also continues on commercial applications. In 1984, the company performed close to 10,000 embryo transfers, most of them for United States sales or contracts.

Alberta Wheat Pool. A farmer-owned cooperative, the Alberta Wheat Pool accounts for the bulk of grain handled in Alberta and for about 65 per cent of the province's grain products. With a head office in Calgary, it is involved in major grain terminals in British Columbia, and in fertilizer manufacturing, canola processing, grain exporting and farm supplies.

A substantial research effort in plant breeding, involving joint ventures with wheat pools in other provinces, focuses on wheat, barley and canola. A subsidiary, Western Cooperative Fertilizers Limited, performs some fertilizer research for Alberta Wheat Pool. The Wheat Pool also does in-house research into herbicides and supports some university research.

BioTechnica International of Canada, Inc. (BTC). Formed in 1985, this Calgary-based biotechnology company is the third element of the BioTechnica International Group which includes BioTechnica International in Cambridge, Mass., and Bio-Technica Limited of Cardiff, Wales. Launched with the commitment of a $12-million investment by Vencap Equities Alberta Ltd., BTC will be the largest biotechnology company in Western Canada. The company will develop and apply advanced biotechnology for the improvement of seed and inoculants for the agricultural industry in Alberta and Western Canada, and for the development of new products and processes for the forestry and energy industries.

For its first major commercial project, BTC will invest $8 million in a research and development project to develop varieties of canola tolerant to important weed killers. Other development opportunities include an inoculant applied to alfalfa and clover seed to increase yield; an inoculant that improves the quality of silage by producing an enhanced fermentation process; a gene that is introduced to brewer's yeast to decrease light beer costs; and technology capable of converting the whey by-product of cheese manufacturing into ethanol.

Norwest Soil Research Ltd. Based in Edmonton, Norwest provides computer and applied research services, as well as analytical services, related to soil, feed, food and pesticides to the agriculture, food and environment industries.

Research is conducted throughout the province in such areas as soil reclamation; soil fertility; nitrogen cycling; and methods of getting better crops and higher yields. Some microbiology, animal husbandry and animal nutrition research is also conducted.

Between one-third and one-half of Norwest's research during the past 10 years has been linked to other industrial, academic or government efforts.

Western Cooperative Fertilizers Limited. The only fertilizer manufacturer in Western Canada with an ongoing research program, Western Cooperative Fertilizers works primarily in the field, focusing on the most productive ways of using fertilizer.

An early leader in the development of banding techniques for applying fertilizer, the company is also involved in research on fall fertilization; effective use of fertilizer under various conditions; long-term effects of fertilizer on soil; nutrients and micronutrients; forage crops which improve soil fertility; ways to more effectively fertilize canola; and the effects of chloride in potash on disease.

Western Cooperative funds some university research and has participated in a number of joint industry and government programs.

Forestry

As the fourth largest province in Canada in terms of productive forest land and growing stock, Alberta has great potential for increased harvesting and for development of a major forest industry.

Alberta's forest resources, both softwood (spruce and pine) and hardwood (aspen and balsam poplar),

are far from fully developed. Alberta is the only Canadian province with a large surplus of uncommitted accessible standing timber. It also has the highest success of reforestation of harvested forest land.

Alberta's research efforts are aimed at intelligent management and protection of its forests, and their rational utilization by industry.

INDUSTRY

Although the forest research needs of the forest industry were traditionally carried out by the Canadian Forestry Service in a cooperative arrangement, a number of companies in Alberta have initiated their own research efforts in recent years, some in the area of new forest products. These include:

Blue Ridge Lumber (1981) Ltd. This subsidiary of Alberta Energy Company Ltd. produces high grade, kiln dried dimension lumber from white spruce and lodgepole pine, and is building a medium density fibreboard plant at its manufacturing complex at Blue Ridge. Research is primarily related to the regeneration of white spruce and lodgepole pine. Under a joint agreement with the Province of Alberta, Blue Ridge Lumber cooperates on projects involving research and development of aspen poplar products, supplying aspen raw material and a portion of the funding for such projects. The company also participates in the Provincial Cooperative Genetic Tree Improvement Program.

Canadian Forest Products Ltd. (CanFor) Operator of a number of stud and dimension lumber mills in Alberta which use spruce and pine, CanFor embarked on a major research and development project in 1984 that will look at a new way of using aspen. The federal government has committed $2.9 million to the project, which involves construction of a pilot plant where a process for using aspen in a combination of finger-jointing and laminating will be researched and developed for possible commercial application.

Pelican Spruce Mills Ltd. In addition to operating sawmills in northeastern Alberta, Pelican recently opened in Edson the first Canadian plant to produce oriented strand board from aspen. Research includes work related to testing and production of the board and to finding alternative uses for aspen bark and sawdust that is currently being wasted.

Procter and Gamble Cellulose Ltd. A participant in the province's genetics program, Procter and Gamble focuses on survival and growth, reforestation and tree improvement. The company also explores the development of new products using aspen at its bleached kraft mill in Grande Prairie.

St. Regis Alberta Limited. A subsidiary of St. Regis Corporation of New York, this company operates a large pulp mill at Hinton. Research is primarily concerned with the growth and yield of natural versus regenerated stands of lodgepole pine. St. Regis has cooperated with the Alberta government in the development of managed sand yield tables and is active in the provincial genetics program.

UNIVERSITIES

The University of Alberta. Most of the forestry program at the University of Alberta is carried out in the Forest Science Department.

Major research projects are conducted in forest genetics; forest seed tree biology; wildland recreation; ecophysiology; forest management; forest measurements, modelling and biometrics; fire science and management; wood science; wildlife productivity; forest soils; forest pathology; reclamation; forest hydrology; forest economics; range management; and forest entomology.

University of Calgary. The Biology Department is actively involved in studies related to control of rooting and flower/seed/cone production in conifers, and methods of micropropagation of various tree species. The Chemistry Department has two separate projects dealing with the nature of chemical communication among animals; the so-called pheromones have potential for application to insect pest control in forestry and agriculture.

THE ALBERTA GOVERNMENT

The Alberta Forest Service (AFS) spends more than two million dollars annually under two major research programs.

Forest Land Management Research. Part of this research is conducted in-house, although some is contracted to other agencies when facilities or expertise are lacking internally. Grants, primarily to universities for long-term projects, are provided through the Forest Research Trust Fund.

In-house research includes: regeneration and growth of seedlings; growth and yield of stands; ecosystem classification; and watershed management. Studies are conducted on ways of converting peatland to productive forestland.

Alberta has an extensive forest genetics program. A cooperative effort of the AFS, industry and universities, this long-term program is conducted at research plots throughout the province, and at

Pine Ridge, the government's forest genetics facility at Smoky Lake.

Forest Products Research. The Forest Products and Forest Industrial Development Research Program is a cooperative effort of the Alberta Forest Service, Alberta Economic Development and the Alberta Research Council. In the fall of 1984, a forestry agreement between the Alberta Forest Service and the Canadian Forestry Service provided a major expansion to the program. Priorities are to assist the forest products industry in increasing productivity; to improve resource utilization; and to develop new forest products and processes, particularly those which would use Alberta's largely untapped aspen hardwood.

The Alberta Research Council. ARC conducts research, development and testing of forest products under the Forest Products and Forest Industrial Development Research Program, using in-house facilities and those of the private sector.

ARC has developed a prototype on-line machine to perform stiffness ratings for panel products and to replace manual inspection and grading of finished products. Other products include one showing that it is technically and economically feasible to produce high-yield pulp from typical qualities of Alberta aspen, and another which has indicated that Alberta aspen and pine are suitable for shingles.

THE FEDERAL GOVERNMENT

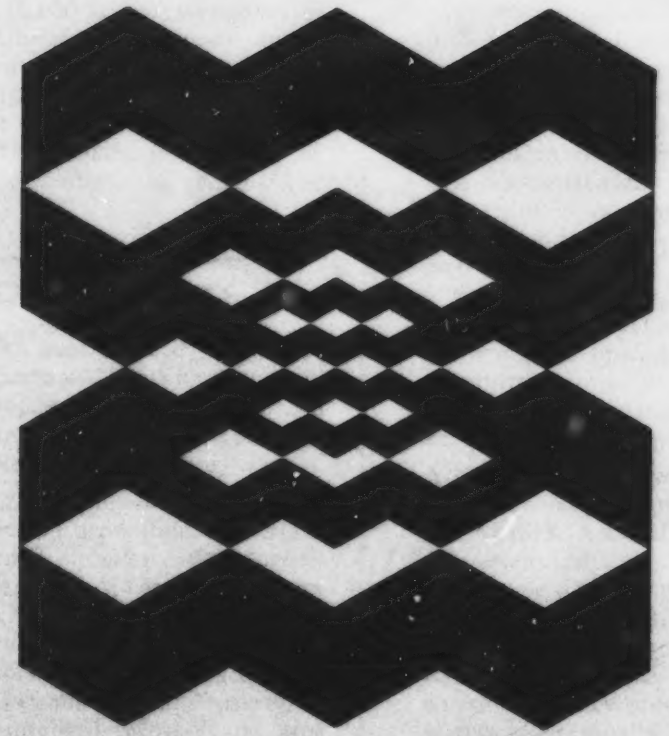
The federal government provides funding to provincial programs through a forestry agreement with the Alberta government. It is also a funding partner with Alberta and other provinces in Forintek, a forest products laboratory located in Vancouver, B.C.

The Canadian Forestry Service, which is both a research investigator and a funder of university and industry projects, operates the Northern Forest Research Centre in Edmonton.

Northern Forest Research Centre. This centre carries out forest research in Alberta, Saskatchewan, Manitoba and the Northwest Territories and was one of the earliest contributors to forestry research in Alberta.

Research is organized under three programs — resources, protection and environment — and includes study of problems in fire, insects and diseases; effects of toxic substances on forest vegetation and soils; and basic problems related to watershed management, forest renewal, forest productivity, forest ecology, resource economics, remote sensing and computer applications.

Energy and Minerals



Energy and Minerals

Alberta is known as Canada's "energy province". With the majority of Canada's remaining established reserves of conventional crude oil and natural gas, the province also boasts the world's largest known recoverable oil sands deposits and more than 80 per cent of Canada's coal reserves. A significant reserve of non-depleting hydro energy is still largely untapped. As a result, Alberta has become a world leader in many aspects of energy resource research and development.

Oil and Gas

While Alberta's vast reserves of conventional oil and gas have historically been the focus of development by the major oil companies, the oil sands deposits which lie under more than 60,000 square kilometres of northern and eastern Alberta hold the greatest future potential for industrial development.

Today, both private and public research and development give considerable emphasis to the economical recovery of oil from the oil sands, as well as to the enhanced recovery of conventional oil and gas. The following are examples.

PETROLEUM COMPANIES

Alberta's energy wealth has attracted many large international energy companies, challenging them to adapt existing technologies or develop new ones to meet the specific conditions found within the province and elsewhere in Canada. Among them are:

Canterra Energy Ltd. A wholly-owned subsidiary of Canada Development Corporation, Canterra is active in all facets of the exploration and production sector in the petroleum industry and is the largest supplier and marketer of sulphur in Canada.

Areas of research and development include improved processing of field seismic data; geological studies of the chemistry and structural makeup of sedimentary rock; improved recovery and production from miscible flooding of hydrocarbon reservoirs; recovery of very sour/high hydrogen sulphide gas from reservoir rocks; hydrogen sulphide phase behavior; corrosion; development of sulphur solvents; and expanded use of computer aided graphics for computer mapping, well log evaluations and time lapse reservoir simulations.

The company also sponsors research programs of such organizations as the Alberta Sulphur Research Institute, the Petroleum Recovery Institute and the Computer Modelling Group, and is participating with the Alberta Oil Sands Technology and Research Authority (AOSTRA) in developing technology in the Athabasca oil sands deposit.

Esso Resources Canada Limited. Esso Resources' Research Centre in Calgary, established in 1955, was the first large oil company research centre to be located in Alberta.

In the area of oil and gas, the greatest research concentration is on heavy oil, particularly thermal (steam) recovery of heavy oil at Cold Lake, where Esso has one producing plant and is planning four more. Some work is also being conducted on the Athabasca Oil Sands.

Frontier production research is another Esso priority. Directed out of Calgary and aimed at conditions in Canada's Beaufort Sea and east coast, this research includes field work and simulations in such areas as ice mechanics and ice forces, soils erosion, and oil spill mitigation.

A substantial research effort is aimed at enhanced recovery of Esso's conventional oil reserves through the use of miscible (gas) displacement and chemical recovery.

Esso maintains a significant research program in key earth science technologies such as seismic data gathering and processing, petrophysics and geochemistry.

Esso also participates in industry and government access programs and projects.

Nova/Husky Research Corporation. This Calgary-based technology centre is owned jointly by NOVA, AN ALBERTA CORPORATION and Husky Oil Operations Ltd.

Drawing on the expertise of an internationally trained team of scientists, the corporation's initial research thrusts have been in the areas of bioscience, as it relates to enhanced oil recovery, corrosion and new product development; chemical science and its possible application in enhanced oil recovery and product upgrading; petrochemistry, including polymers and chemical processes; geoscience, particularly in offshore and frontier exploration; the gas and fluid dynamics of pipeline operations; and electronics and instrumentation development for operational needs.

Nova/Husky is involved in a number of research organizations and government programs.

Shell Canada Limited. Shell's $21-million Calgary Research Centre provides a focus for all of the company's upstream research and development in Canada.

Shell's three main areas of research — enhanced oil recovery, oil sands development, and materials and corrosion studies — are associated with development of the company's large oil and gas resource base in Alberta.

Research efforts include work aimed at improving the ability to predict rock porosity and permeability to allow more economic exploration for oil and gas. Shell is also involved in petrophysical and geophysical instrument development, such as a system which would eliminate the need for radiotransmitted signals to start seismic recorders, often a problem in hilly or mountainous areas.

In Calgary, Shell is studying the enhanced recovery of conventional oil through miscible flooding, and enhanced oil sands recovery through steam and hot water injection and combustion.

Major studies are directed at the behavior of metallic and non-metallic materials when exposed to operating conditions; at the investigation of new materials; and at the use of chemical inhibitors for corrosion control. Shell also conducts extensive research in production chemistry.

Shell participates in a variety of AOSTRA-funded university projects and is a member of a number of government and industry research groups.

Suncor, Inc. Suncor opened the world's first commercial plant for extracting oil from oil sands in 1967 near Fort McMurray and conducts an ongoing research and development program on that site.

A major Suncor project, undertaken with McGill University in Montreal, focuses on the recovery of bitumen from sludge and has involved construction of a $3-million pilot plant and an annual expenditure of about $1 million.

Other current Suncor research efforts include development of bitumen skimmers to recover bitumen coming through the tailings line; mining techniques for efficient recovery from waste zones; and improvements to extraction, mining and recovery technologies. Some of these projects are carried out in concert with AOSTRA.

Syncrude Canada Ltd. Syncrude operates the world's largest commercial oil sands plant near Fort McMurray, and one of the province's largest private research labs near Edmonton.

Syncrude spends about $15 million on research and development, including environmental work and geology, each year, with the lion's share spent on the highly applied activities of its lab.

The major area of interest is oil sands mining technology, in which Syncrude is a world leader, and extraction processes, especially the hot water extraction process currently being used.

Syncrude research also is directed at the handling and operation of equipment in a cold climate; overburden removal; tailings disposal; enhanced recovery of bitumen from tailings; testing and improvement of materials; and the development of instrumentation.

Syncrude works closely with the University of Alberta in areas such as oil sands analysis and participates in a number of AOSTRA and other government programs.

Texaco. The research and development efforts of Texaco Canada Resources Ltd. are focused on economic in-situ recovery from the Athabasca Oil Sands. Experimental work continues to evaluate displacement mechanisms, a variety of additives and a unique patented sand control device. Additional studies relate to the physical and chemical characteristics of bitumen emulsions in order to refine emulsion treating methodology. Further oil sands topics include waste water treatment and water recycling. Much of Texaco's research and development is carried out under contract to ARC.

UNIVERSITIES

The University of Alberta and the University of Calgary are involved significantly in petroleum research. Both encourage industry involvement in funding of specific projects, joint ventures and contract testing work.

University of Alberta. Research within the University of Alberta's Mineral Engineering Department includes work on heavy oil and oil sands recovery methods, conventional oil recovery and related areas of metallurgy and mining and mineral processing.

The University's Chemical Engineering Department has developed a strong research effort in support of the natural gas industry in such areas as thermodynamics and phase behavior, chemical reaction and catalysis, and computer process control. In the University's Science Faculty, the Chemistry Department is investigating the thermodynamic properties of oil sands; the Geology Department studies petroleum migration, computer use in resource evaluation, and trace fossil assemblages and their relation to oil bearing structures; and the Physics Department is studying seismicity in heavy oil recovery, and fluid mechanics as it relates to oil bearing deposits.

University of Calgary. Members of the University's Engineering Faculty conduct research related to the exploitation and processing of heavy oils and

oil sands. An in-situ combustion tube developed at the University is contracted out for use by industry worldwide. Other work is being done on the desulphurization of coke from oil sands processing plants; the utilization of sulphur; the tertiary recovery of oil; fluid dynamics; effective energy utilization; and instrumentation.

The Chemistry Department is undertaking basic and applied research on the Alberta oil sands; on chemical properties and applications for oil recovery; and on sulphur. The Geology Department undertakes field and laboratory research in stratigraphy, palaeontology, sedimentology, petrology, structure, petroleum geology, ore deposits, exploration geophysics and engineering geology. Specific research in progress concerns mineralogical changes that take place during steam treatment and the effect of such changes on reservoir properties and recovery efficiency. Other studies concern the effects of pore geometry, wettability, and interfacial tension on fluid migration in conventional reservoirs, with the goal of improved displacement efficiency during secondary and tertiary recovery.

THE PUBLIC SECTOR

The Canadian and Albertan governments are heavily involved in research and development in the energy field, primarily by providing funding and services to support the research efforts of universities and private industry.

The two most prominent government agencies active in this area complement private industry and the universities in such a way that the public and private sectors are almost inseparable. These agencies are:

Alberta Oil Sands Technology and Research Authority (AOSTRA). AOSTRA funds industrial, university and other research related to oil sands, heavy oil and enhanced recovery of conventional oil, with major interests in in-situ oil sands projects, carbonates, mining/extraction, underground access, upgrading, and technology handling.

AOSTRA is funding the construction of an Oil Sands Demonstration Centre in Fort McMurray, which will accommodate large-scale, long-term testing of new oil sands technology by industry on a user-pay concept; and an underground test facility on the Athabasca Oil Sands, where industry can explore the extraction of oil from underneath, rather than above, the deposit.

Alberta Research Council (ARC). ARC works closely with industry and government on contracts for oil sands research and makes available to industry information generated from a joint research program with AOSTRA.

ARC's oil sands research program focuses on the in-situ recovery of bitumen from oil sands and on ways to make these techniques more economical. The program provides assistance for in-situ research up to the operation of a field pilot — including piloting and physical simulation; numerical modelling; physical parameters and fluid-rock interactions research; geology; laboratory analytical systems; and information systems.

ARC conducts geological research and survey programs to support oil sands research and to generate public information. These programs include petrologic studies, facies analysis of subsurface and surface sequences and interpretive mapping of entire deposits.

ARC operates the Alberta Oil Sands Information Centre under contract to AOSTRA. The Centre acts as a central source of all published information on oil sands, enhanced recovery processes and heavy oils. ARC also operates the Oil Sands Sample Bank, which provides detailed characteristics and samples of oil sands, bitumens and heavy oils in various Alberta recovery projects. These samples are shipped at cost to organizations and institutions in Canada and abroad.

THE SEISMIC INDUSTRY

About one-seventh of the world's seismic industry is centred in Alberta, primarily in Calgary. While the universities have made significant contributions, it is mainly the work of private industry that has earned Alberta an international reputation for excellence in this field. Examples of firms conducting research in this area are:

Digitech Ltd. Offering a full range of geophysical processing and modelling, geological mapping and data base retrieval services, Digitech conducts a million-dollar-a-year research effort from its head office in Calgary. Major emphasis is on computer-assisted processing of geophysical and geological data for the resource industry.

Digitech is currently involved in an innovative project which would transfer Digitech software into interactive graphic work stations that could be used by exploration geologists and geophysicists. Digitech has an international marketing agreement with the American manufacturer of the hardware involved, and prototypes of the new system are already installed at customer sites in both Canada and the United States.

Teknica Resource Development Ltd. Teknica is internationally recognized as a source of high technology seismic software and expertise. It is also the only Canadian company doing large integrated international geological petroleum basin studies,

including research into hydrocarbon sources and maturation.

One of its most significant developments is a seismic inversion process which allows seismic imaging of the subsurface geological sequence to reveal rock type as well as rock shape. Under favorable conditions, the process will allow mapping of the extent and distribution of a new reservoir prior to drilling.

To help in the evaluation of information obtained through this and other techniques, Teknica pioneered in the application of color displays, now used around the world. Teknica is currently involved, with funding support from a number of large petroleum companies, in developing an innovative exploration and development software program that will use optical discs for storage and enable easy retrieval and handling of massive amounts of seismic data.

Veritas Seismic Ltd. This subsidiary of Veritas Resource Services Ltd. of Calgary is primarily involved in processing seismic data for oil exploration. Research and development, at a budget in the order of $1 million per year, are carried out by Veritas Software Ltd., a subsidiary of Veritas Seismic Ltd.

Research efforts at Veritas have been directed largely toward developing algorithms for solving seismic processing problems peculiar to Western Canadian exploration. Veritas supported a recent research project at the University of Southern California which resulted in a new type of deconvolution particularly applicable to Canadian conditions. The company is now supporting a project at Stanford University which may yield similar results in the area of multiple elimination.

In 1985, Veritas Software entered into a joint venture agreement with ARC to develop a computer software package for the Vertical Seismic Profiling (VSP) and seismic tomography industries.

Future efforts will be aimed at broadening the research spectrum to development of seismic interpretation aids for use on interactive work stations.

ICE RESEARCH

With the Geological Survey of Canada estimating proven reserves of oil in the Beaufort Sea at 737 million barrels and potential reserves at 9.2 billion barrels, it is no surprise that oil companies based in Alberta have spent hundreds of millions of dollars studying ways to find, produce and transport oil and gas from the ice-infested waters of the Canadian Arctic.

The efforts of these companies and of university and government agencies have made Alberta, and particularly Calgary, a world centre for ice research. While most work is related to arctic waters, some is also focused on other frontier areas. For example:

ARCTEC Canada Ltd. A Canadian, employee-owned, marine oriented company specializing in cold regions engineering and located in Calgary, ARCTEC develops concepts, and designs and tests ships and structures for use in the arctic and subarctic marine environments. Acknowledged as a world leader, ARCTEC uses its 30-metre ice model basins to investigate and measure the ice-worthiness of a ship or structure prior to construction. ARCTEC has tested, in both model and full scale, virtually all the Canadian icebreakers and offshore Beaufort Sea structures built in the last 12 years.

ARCTEC's clients are located in many countries around the world that have ice-related problems, including the United States, U.S.S.R., Finland, Japan, China, United Kingdom, Sweden and Singapore.

Current work is directed at structure/ice and ship hull/ice interactions, including the load/area distribution and structural response. In addition to designing, constructing, calibrating and installing large (2m x 3m) ice load sensing panels and in-situ instrumentation and data acquistion systems for structures, ARCTEC conducts analytical studies by means of computer-based F.E. and surface element models. ARCTEC is the agent for the AQWA suite of computer-based hydrodynamic floating body motion and response program. Using full diffraction theory, this non-linear program is state-of-the-art.

Det norske Veritas. A major international ship classification society headquartered in Norway, Det norske Veritas opened its Cold Climate Technology Centre in Calgary in 1981. This centre is the major cold climate research body for the society, which acts as a regulatory body in classifying and approving designs of vessels and offshore structures.

The Calgary centre conducts research on arctic submarine pipelines, ship-ice and structure-ice interaction, ice mechanics, materials technology, and risk and safety aspects of offshore exploration.

Dome Petroleum. A very active player in the Canadian Arctic, this Calgary-based oil company uses the Beaufort Sea as a huge laboratory for testing of icebreakers, artificial islands and state-of-the-art technologies. It is also very active in ice monitoring.

All of Dome's arctic drilling and engineering is carried out by its subsidiary, Canadian Marine Drilling Ltd. (Canmar), which developed both the Kigoriak icebreaker and its successor, the Robert Lemeur. The hull of the Robert Lemeur is a one-third scale model of the icebreaking tanker Dome hopes will transport oil to southern ports. An

icebreaker capable of year-round operation is also under development.

A research project in the high Arctic on Hans Island, where ice forces were studied for the first time on a large scale, led to the construction of Dome's Tarsuit artificial island in 1981. Tarsuit was the first caisson-retained island in the Arctic and the first to achieve year-round offshore drilling capability.

Esso Resources. Frontier production research is an Esso priority. See the Esso listing earlier in this section for details.

GEOTECHnical resources ltd. Based in Calgary, GEOTECH offers advanced applied technology in engineering and geosciences. The company's main markets are the resource industry, government departments and other service companies.

GEOTECH's Engineering Division staff members have served the needs of arctic offshore exploration from Alaska to Labrador, applying engineering principles and practices in innovative ways to solve problems for which standard practices were not applicable. The group's ability to apply a multi-disciplinary approach to project planning, design, execution, and management has been demonstrated throughout a vast range of assignments including large-scale projects such as the iceberg impact simulation test program, the recently completed medium-scale multi-year ice indentation test program, and the grounded sprayed ice drilling island.

Within the Engineering Division, the Arctic Group provides cold room laboratory services as well as Arctic field services including monitoring, measurement, testing and construction related to both ice and permafrost. Arctic Group staff members with over 50 years combined experience in the Arctic offshore are available to plan, direct, and execute innovative projects in this rigorous environment.

THE PETROCHEMICAL INDUSTRY

Starting in 1941 with Canada's first petrochemical plant, Alberta now has more than half of the nation's petrochemical industry, based on natural gas feedstocks. Research and development in petrochemicals is an ongoing activity of many major oil and gas producing companies, and fine opportunities exist for further private industry involvement.

Dow Chemical Canada Inc. Dow conducts a research effort of about $1.8 million annually from its petrochemical complex at Fort Saskatchewan.

In addition to process-type research, Dow conducts research in areas of direct interest to the Alberta market, such as development of agricultural herbicides.

Dow is also involved in development and testing of company products used in other industries, including the petroleum and pulp and paper industries.

Novacor Chemicals Ltd. Novacor was formed in 1981 to direct and operate the petrochemical interests of its parent company, NOVA, AN ALBERTA CORPORATION.

Headquartered in Calgary, Novacor produces linear low density polyethylene near the Joffre ethylene facilities of its wholly-owned subsidiary, The Alberta Gas Ethylene Company Ltd. Another subsidiary, Alberta Gas Chemicals Ltd., owns and operates three methanol plants in Medicine Hat.

The Novacor Technical Centre in Calgary focuses on state-of-the-art technology and product development related to linear low density polyethylene, polyvinyl chloride and other thermoplastic production and applications. Additive and catalyst research is also performed.

OTHER RESEARCH

Significant research has been undertaken by the private and public sectors in support of Alberta's oil and gas industry and its byproducts. Examples include:

Alberta Sulphur Research. This non-profit organization supports basic research into the chemistry and technology of sulphur and its compounds. The research group, housed at the University of Calgary, concentrates on problems in production, separation, conversion, handling, transportation and end use of sulphur and sulphur compounds involved in the sour natural gas industry.

The agency is supported by member companies to serve as a research and training bridge between industry and academia.

Bow Valley Resource Services Ltd. Bow Valley and its affiliated companies provide contract drilling and supplies to the international petroleum industry. In addition to environmental high technology research and development performed by its Western Research Division, Bow Valley coordinates from its Calgary head office multi-million-dollar research efforts that have included development of offshore drilling rigs and equipment, a Mobile Arctic Island and a wide range of specialized instrumentation and equipment for the energy, forest, trucking and mining industries.

Centre for Frontier Engineering Research (C-FER). Created in 1984 with funding from the Devonian Group of Charitable Foundations, the Governments of Alberta and Canada, the University

of Alberta and the private sector, C-FER addresses problems related to materials, design and construction of structures required for arctic and offshore resource and development.

C-FER's core research is comprised of two main programs. The Centre's main research initiative, steel structures for the Arctic, is aimed at the development of a rational design procedure for steel structures to be used in low temperature environments. It is comprised of several specific projects including: toughness and corrosion susceptibility of welded plate; extension of structural analysis programs to incorporate factors such as brittle fracture; and dynamic characteristics of ice loading. The second major thrust, downhole tubular products, focuses on factors of significance in the design of drillpipe, casing and production tubing for the harsh environments on Canada's frontiers.

Computer Modelling Group. This non-profit research group is one of the leaders in reservoir simulation. It is supported by member organizations from around the world and through contract, consulting and service fees received from industry and government agencies such as ARC and AOSTRA.

The Calgary-based company develops technology for the computer modelling of in-situ recovery techniques for hydrocarbon resources. It also has an applications group to assist industry in hydro carbon recovery optimization through reservoir model studies.

D & S Consulting Group. D & S is a multi-disciplined Calgary company which provides professional consulting services, software products and computer services to the petroleum industry on a worldwide basis. The company deals with all aspects of exploration, drilling, development, production, economics, reservoir engineering, enhanced recovery, computer modelling and project management.

Current research includes work on improved methods of reservoir simulation, including the FAST suite of reservoir simulators, and development of implicit software formulation techniques. Another area of interest, improved methods of petroleum data management, has led to development of the FORTE system for handling land interests, wells, reserves, revenues and cash flows.

GEOTECHnical resources ltd. This Calgary company offers advanced applied technology in engineering and geosciences. See listing earlier in this section for details on the company's arctic research efforts.

GEOTECH's Engineering Division offers a broad range of engineering, research and development capabilities. It provides environmental, civil, mechanical, electrical, electronic, and instrumentation engineering services as well as physical sciences tailored to the requirements of both industry and government.

GEOTECH's capabilities include specialty tests and procedures in the areas of routine and supplementary core analysis; research and engineering services; petrophysical studies; arctic project management; chemical anaysis; and laboratory equipment design, development and fabrication. All aspects of the company's operations are supported by a computer services group which has introduced innovations in computer graphics, data acquisition and instrumentation control.

Petroleum Recovery Institute. A non-profit research organization based in Calgary, the Institute conducts research on the enhanced recovery of oil from underground reservoirs. More than 25 petroleum companies are members of the Institute, which is financed through annual fees, an AOSTRA research grant and revenue from contract research performed for industry and government.

Current areas of focus include miscible and immiscible flooding with hydrocarbons, carbon dioxide, nitrogen and other inert gases; the application of steam and additives for improving recovery of heavier oils; the use of sweep improvement, such as mobility control measures or the use of diverting or blocking mechanisms, to increase productivity; and chemical flooding.

Sulphur Development Institute of Canada (SUDIC). A non-profit organization supported by members of the sulphur industry and the Alberta and federal governments, SUDIC is most heavily involved in technology transfer related to developing new uses of sulphur.

The Institute concentrates on three areas of commercial merit: sulphur extended asphalt (SEA), for which the Institute has patented technology in commercial use in North America; a sulphur concrete technology, SUDICRETE, based on work done at the University of Calgary which has particular promise for construction uses in acid and salt environments; and the use of sulphur as a fertilizer.

Technifluids, A Division of Trans Canada Resources. The largest Canadian-owned supplier of drilling fluids, Technifluids performs the majority of research and development for Trans Canada, a Calgary-based oil and gas company, and its other divisions. Most of that research is in the drilling fluids area, including a major project partially funded by the federal government and involving high temperature and high pressure testing of drilling fluids. Other key areas of research interest include corrosion control, sour gas well monitoring and drilling and production chemical development.

Technifluids also participates in other government and industry research programs.

UMATAC Industrial Processes, A Division of UMA Engineering Ltd. Headquartered in Calgary, UMATAC specializes in research and development related to the Taciuk Processor, a new method of processing heavy oil sands. AOSTRA has contributed $13 million to the development of this processor over the past nine years.

The Taciuk Processor differs from hot water and other conventional extraction processes in that it accepts as-mined oil sands, processing it simultaneously to recover and thermally upgrade hydrocarbons. The processor could eliminate a number of treatment aspects, such as the need for water and waste tailings ponds.

Major tests of the processor have been made on Malagasy oil sands feed stock and its use is also being tested on oil shales in Canada and the United States. A $100-million demonstration project is being planned.

Coal

Alberta's huge coal reserves have the same energy potential as all known reserves of oil sands and heavy oil combined in the province. Recent government initiatives, along with ongoing industry activities, are giving research and development related to coal new priority

PRIVATE INDUSTRY

Alberta Power Limited An investor-owned electrical utility, Alberta Power supports the national research and development efforts of the Canadian Electrical Association (CEA) and works hand-in-hand with other companies and government bodies involved in coal research. It co-funds with and is the only utility involved with the University of Waterloo in a CEA project at Battle River which is looking at boiler monitoring to control slagging and fouling.

Coal Mining Research Centre (CMRC). Located at the Coal Research Centre in Devon (near Edmonton), the CMRC is a private, non-profit company controlled by the coal industry, with representation on its board from the federal government and the governments of each of the three Western Canadian coal-producing provinces. Originally funded through the Alberta/Canada Energy Resources Research Fund, the CMRC is now solely supported by the contract research work it performs for industry and government.

The CMRC is dedicated to fairly short-term applied research projects which can be expected to yield immediate economic benefits to industry in such areas as coal mining, coal preparation and workers' health and safety.

Crowsnest Resources. This subsidiary of Shell Canada spends between $500,000 and $700,000 on research and development each year. Current interests include coal petrography, coal quality, advanced methods of cleaning coal, and coal transportation. Crowsnest supports research in metallurgical coal through the Canadian Carbonization Research Association, as well as university, in-house and other research efforts in such areas as coal utilization, advanced methods of coal testing, combustion and flame stability.

Esso Resources Canada Limited. About 85 percent of the $1.9 million worth of minerals research done each year at Esso's Research Centre in Calgary is devoted to coal. Areas of emphasis include coal quality improvement; coal performance in various applications; automated coal microscopy; and coal mining studies, including development of mine face ash measurement instrumentation.

Luscar Ltd. A major integrated coal company headquartered in Edmonton, Luscar focuses its research and development primarily on the pilot demonstration of improvements in reclamation, water management, dust abatement and beneficiation, in presenting coal in a more marketable and environmentally acceptable format. This work is carried out in conjunction with its research and development in liquefaction, coal fuel slurries, improved geophysical techniques, and the evaluation of alternate equipment and mining methods.

Luscar works closely with Alberta Research Council, the Coal Mining Research Centre, the National Research Council, the Office of Coal Research & Technology, Canmet and other academic, government and research institutes in developing and applying the emerging technology to the coal industry.

Manalta Coal Ltd. With a substantial research effort based in Calgary, Manalta has worked with ARC on research into groundwater and the regional effect of prairie mining. It is a participant in Alberta's reclamation research program and other environmental studies, and has a number of in-house programs.

Current projects include studies of agglomeration and other processes to improve the market quality of coal, work on improved methods of coal transport, and development of computer software to assist in mine planning.

Pembina Resources Limited. Part of the Loram Group, Pembina Resources has a research group located in Calgary and recently completed a

Research Centre at Longview, Alta., to study the feasibility of moving bulk commodities, particularly coal, by pipeline.

Pembina was involved in a coal transport study, jointly funded by Alberta Energy and Natural Resources through the Alberta/Canada Energy Resources Research Fund. It works with Manalta on coal agglomeration and is studying the hydraulic properties of densely loaded coal-water mixtures, coal beneficiation and enhanced oil recovery. Pembina has been involved in the application of pneumatic capsule pipelines to move coal and wood chips.

TransAlta Utilities Corporation. TransAlta supplies 80 per cent of the power in Alberta, 90 per cent of which is generated from coal, and conducts extensive process and environmental research related to its use. The company is involved with Westinghouse Canada in studying the economics of using Alberta coal in a coal gasification combined cycle power plant technology. It is the only Canadian utility participating directly in development of an experimental process developed by Rockwell International for more economically reducing the acid gas emissions from coal-fired power plants.

UNIVERSITIES

University of Alberta. The Mineral Engineering Department of the University's Engineering Faculty is conducting coal research in such areas as flotation, liquefaction, gas extraction, upgrading, slaking of clay partings, and the economics of mining. Computer data base systems applied to the study of coal-bearing strata have been developed in the Geology Department, and studies of coal-bearing geological structures are ongoing. In the Mathematics Department, work is in progress on the modelling, analysis and simulation of coal liquefaction reactors.

University of Calgary. In the University's Chemistry Department, coal research focuses on spontaneous combustion of coal dust and the relationship to various surface chemical species of coal. In Geophysics, seismic exploration techniques for oil and coal are being explored which involve three-dimensional imaging in seismic signal processing.

THE PUBLIC SECTOR

The Alberta government's involvement in coal research and development is aimed at supporting the efforts of industry, universities and other research organizations. The following agencies play key roles:

Alberta Research Council. ARC's Coal Research Program includes: geology studies; research on liquefaction to convert coal to marketable fluids such as fuel oil and syncrude; pyrolysis to convert coal partially to liquids and gases and partially to a solid fuel which can be burned in thermal power stations; underground coal gasification, which produces fuel gas; and coal property definition. ARC also researches marketing alternatives for coal.

CANMET Coal Research Laboratory. Part of the Canada Centre for Mineral and Energy Technology, the federal Coal Research Laboratory is located in the Coal Research Centre at Devon. This laboratory has been serving the coal industry in Western Canada for more than 30 years, developing new and more efficient methods to prepare coal for market.

The laboratory operates a permanent pilot plant, unique in Canada and rare in the world, which has contributed to coal preparation procedures used around the world. The laboratory also conducts extensive studies on improving the quality of effluent water from coal washeries and performs comprehensive testing programs in carbonization. As well, the laboratory has an established program for treating oil and water emulsions from in-situ recovery of bitumen from oil sands or from enhanced recovery.

Coal Research Centre. One of the two largest coal research centres in Canada, this $22-million centre was built with funds from the Alberta/Canada Energy Resources Research Fund to encourage the growth of an efficient and productive coal mining and processing industry in Canada. Located at Devon (southwest of Edmonton), it houses ARC coal research activities, the Coal Mining Research Centre and the CANMET Coal Research Laboratory.

Office of Coal Research and Technology. This office promotes and helps coordinate the funding of research and development of new technology, with a primary focus on enhancing the competitiveness of Alberta coals in international markets, minimizing the environmental impact of the production or utilization of coal in Alberta, and developing new uses for Alberta coals.

The office works closely with industry and other agencies, and funding of approximately $20 million has been allocated from the Alberta/Canada Energy Resources Research Fund to help provide financial support for approved research projects.

Other Energy Research

Through its department of Energy and Natural Resources, the Alberta government works with industry, ARC and the universities on research related to energy conservation and the use of renewable energy sources.

The department's Energy Conservation and Renewable Energy Program, financed by the Alberta/Canada Energy Resources Research Fund, supports the Solar and Wind Energy Research Program (SWERP) and the SWERP Information Centre. Other projects range from energy conservation in natural gas processing operations and in buildings, to wind-energy research, development and demonstrations.

Government, university and industry involvement in non-petroleum energy research includes:

Wind. A Small Wind Turbine Demonstration and Test Site, north of Lethbridge, was initiated in 1982 by Alberta Agriculture, in cooperation with ARC, to provide potential users (Alberta farmers) of small wind turbines with adequate information regarding the technical and economic performance of these turbines.

Deltx Windpump Corporation of Calgary, for example, is looking at the design, performance, and economics of a delta-blade wind turbine system for application to a variety of direct water-pumping uses.

TransAlta Utilities, also interested in the potential development and use of wind energy technology, is looking into increasing energy production at one of its 13 hydro plants by using wind to pump water from below to above the dam.

Energy Efficiency. Energy efficiency in building construction has been the focus of a number of projects undertaken by the University of Alberta's Mechanical Engineering Department in conjunction with various industrial concerns. The Department operates the Alberta Home Heating Research Facility, in which heating and insulation strategies applicable to houses are evaluated. Companion studies involving air infiltration, use of solar energy, and computer simulations are also considered. In addition, research is ongoing in the area of lowgrade heat recovery, heat transfer studies under icing conditions and the use of closed tube thermosyphons in heat transfer. Further studies include research into turbulence-enhanced combustion for lean fuel air-mixures, and the efficient starting of diesel engines at very low temperatures.

Minerals

Most of Alberta's mineral wealth is nonmetallic, but the province's abundant energy supplies have attracted some companies involved in metallic mineral research. These include:

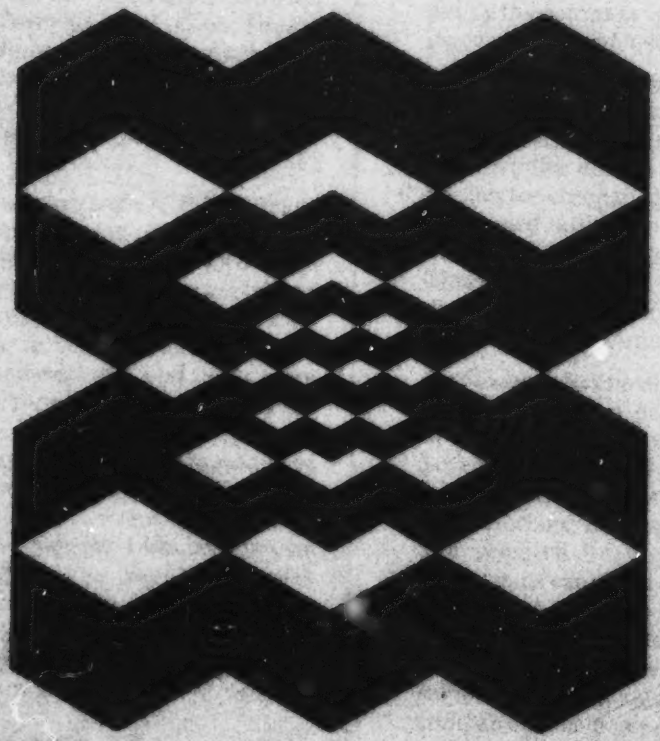
Esso Resources Canada Limited. Esso's geostatistics and other nonfossil-fuel mineral studies are conducted out of its Research Centre in Calgary. The company, which is primarily interested in zinc, copper, lead and precious metals, has various mineral holdings across Canada.

Sherritt Gordon Mines Limited. For over 30 years, Sherritt has operated a nickel and cobalt refinery at Fort Saskatchewan which has led to diverse metal fabricating facilities. Sherritt is also a very large producer of nitrogen and phosphate fertilizer. The plant site is also home to Sherritt's Technology Group, about 140 people employed by the Research Centre and the Development and Engineering Department.

Much of Sherritt's multi-million dollar research, development and engineering effort is a technical service to production plants to improve the metal refining processes, which are based on pressure hydrometallurgy. Refined nickel and cobalt metal are the principal products, while sulphur is recovered as fertilizer-grade ammonium sulphate by-product and, not, as is often the case, undesirable sulphur dioxide.

Sherritt conducts extensive physical metallurgy research and development on new metal products to enhance its fabricated metal business. Chemical or hydrometallurgical research is devoted to the development of unique extractive metallurgical processes and process technology for the recovery of metals such as nickel, cobalt, copper, zinc, uranium and precious metals. These processes are available for licensing and are in use in several countries around the world.

Environment



Environment

Since the quality of life in Alberta is closely tied to its abundance of fresh air, clean water, good soils, wildlife habitats and recreational parklands,there is a strong environmental awareness in the province.

Alberta was the first province in Canada to establish a department specifically to be responsible for the environment. The province now generates a broad, interdisciplinary spectrum of environmental research.

THE PRIVATE SECTOR

Virtually all petroleum companies with operations in Alberta have environmental research groups responsible for carrying out environmental assessments in association with their production activities. These include Shell, Petro Canada, Esso, Husky, Nova, Pan Canadian, Dome, Home, Chevron, Mobil, Amoco, and Canadian Superior, among others. Some also conduct extensive environmental research programs, a sampling of which are outlined in this section.

Canadian Petroleum Association (CPA). A trade association of oil companies which is headquartered in Calgary, the CPA is concerned with environmental, economic and technical matters related to the oil and gas industry. The CPA performs much of its research in cooperation with other industry groups and government, and funds more than a third of the Government/Industry Acid Deposition Research Program.

Recent research projects have included studies of containment and recovery of oil spills; development of computer models for improved prediction of dispersion of oxides of nitrogen from compressor stations; use of incinerators for disposal of wastes associated with certain types of filters; safe disposal of waste sludges from gas plants; improved disposal of diesel-based drilling muds; the feasibility of land farming oil sludges; and the impact of brine spills on the environment.

The CPA has supported major research in pipeline crossing techniques which minimize environmental damage and in reforestation after seismic and pipeline work. It has also developed industry guidelines for environmental protection through effective waste management.

Canterra Energy Ltd. Calgary-based Canterra Energy coodinates environmental research and monitoring related to its exploration and production activities in Alberta, Saskatchewan, British Columbia, and the East Coast frontier. In addition to work on air and water quality, and the concerns related to its production facilities (primarily in Alberta), Canterra has a major interest, because of its sour gas resources, in the effects of sulphur on soil and vegetation. To this end, the company initiated in 1981 a five-year research program with the Canadian Forestry Service Northern Forest Research Centre looking at plant ecological effects of sour gas processing in west central Alberta; participated in the West Whitecourt Study, which is also looking at sour gas effects on vegetation; and is an industry participant in the Acid Deposition Research Program. Other research is being carried out by the company in areas of reclamation, waste management, and wildlife management.

Crowsnest Resources. Crowsnest's environmental research program includes involvement in the provincial Reclamation Research Program. Reclamation studies on two scientifically-designed plots on sites the company plans to develop in the future are aimed at improving reclamation practices during the earlier, operational phases of mining. Through its Calgary office, the company directs research into the effects of mining on wildlife and vegetation in southeastern British Columbia.

Gulf Canada Resources Inc. Most of Gulf's environmental research is performed out of its Calgary office, in conjunction with its drilling group. Several projects relating to toxicity of diesel-based muds include feasibility studies on using solvent to wash cuttings, development of a non-toxic fluid, and research on ways to solidify cuttings so compounds cannot be washed out.

Gulf is also looking at alternative uses of wastes; safe re-cycling of waste containers; fate and effects of metals in waste water ponds; and reclamation of sulphur blocks and underlying base from soils. The company participates in other industry, university and government research.

Shell Canada Limited. Shell is involved in environmental research through a variety of avenues, including wholly-funded projects, projects funded jointly by several companies or industry associations, and those funded jointly by industry and various government agencies. Research focuses on identifying the presence of environmental impacts caused

by company or industry activities. The range of studies is wide, including long-term effects of airborne emissions on soils, livestock, vegetation and human health; effects of drilling activities on wildlife populations; disposal of waste products; and development of techniques for reclaiming lands disturbed by company activities.

Suncor Inc. As part of a multi-million-dollar annual commitment to the environment, Suncor participates in Alberta's Reclamation Research Program in the oil sands and has several related projects underway at its Fort McMurray plant. Projects include research into reclaiming tailings ponds after mining, reclaiming the solid surface through replacing soils and vegetation, reclamation of sulphur piles, management alternatives for various wastes, plume dispersion modelling and impact studies.

Syncrude Canada Ltd. Syncrude's extensive environmental research program is coordinated through its Edmonton office, with field work performed in Fort McMurray. The company is involved in Alberta's Reclamation Research Program and conducts land reclamation research in such areas as reclamation of tailings sand and overburden, and native tree and shrub germination and propagation.

Other areas of Syncrude research include aquatic reclamation, including aquatic toxicological and detoxification studies on tailing water; air quality, including work in computer prediction and modelling; and impact assessment, particularly related to the effects of Syncrude's operations on air, water and land quality. The company is involved in a number of cooperative programs with industry, universities and government.

TransAlta Utilities Corporation. In addition to work on reducing sulphur emissions from coal, TransAlta has a number of other environmental research thrusts. The company is investigating methods of re-vegetating ash lagoons associated with its power plants. It is also conducting research into native trees and shrubs and their effective establishment after a mine is complete; productivity of reclaimed land; and methods of dealing with soil sodium problems. TransAlta also cooperates in Alberta's Reclamation Research Program.

UNIVERSITIES

The University of Alberta has several environmental and biological research stations. Individual research efforts are found in a number of departments.

The Department of Mechanical Engineering has several ongoing facilities involved in projects related to the atmospheric dispersion of pollutants, icing of structures and aerodynamic design. Since August of 1984, it has operated the Mechanical Engineering Acoustics and Noise Unit (MEANU). This is a facility which integrates a commercial acoustics testing laboratory with an educational research facility. The lab considers commercial testing for acoustic absorption and transmission properties of materials and material systems.

The Biological Sciences Centre of the Faculty of Science houses the Controlled Environment Facility, one of North America's largest areas to study the effects of specific environmental factors on living organisms. The Department of Botany, which administers this facility, also has ongoing research examining the effects of oil spill chemicals on shoreline vegetation. Major research on the development of Native grasses for coal reclamation has been performed in the Department of Genetics. The use of micro-organisms for the cleanup of oil and oil byproduct spills is being developed in the Department of Microbiology. The Department of Zoology has projects studying the factors which control lake productivity and eutrophication. Studies of erosion, man-induced disturbances in the Arctic, acid rain, air pollution, and water resources take place in the Geography Department.

The University of Calgary's Faculty of Environmental Design, Physics Department, and Department of Mechanical Engineering are involved in environmental research. The Physics Department conducts studies in aeronomy and atmospheric physics pertinent to studies of air pollution. The Department of Mechanical Engineering has low-speed wind tunnels specifically designed for environmental aerodynamic studies. It also does studies of the dispersion of gasses from tall stacks.

Several agencies devoted exclusively to environmental research are associated with the University. One of these is the Kananaskis Centre for Environmental Research, where major projects deal with environmental aspects of resource development in western and northern Canada. A large ($3-million) acid rain research contract was recently awarded, while other studies include ethylene air pollution and environmental toxicology. Another such agency is the Arctic Institute of North America, which encourages research into the Arctic and middle North and operates field stations in the Yukon and Northwest Territories.

Researchers at the University of Lethbridge have also received government funding for environmental projects.

PUBLIC SECTOR

Federal agencies such as the Canadian Wildlife Service, Environment Canada and Agriculture

Canada have participated in environmental research in Alberta, and federal funding supports various projects in the province. But, the leading role in environmental research in Alberta is played by the provincial government and its agencies.

Alberta Environmental Centre (AEC). The Alberta Department of Environment supports the AEC, which provides applied research, development, and analytical and laboratory services to provincial departments and agencies in the following areas:

Analytical, Diagnostic, Extension and Technical Services. Services include pest management; microbiological identification; trace organics analysis and methods development; air and water analysis; precipitation studies; toxicology; geochronology; lake nutrients; aquatic biology; and quality control and data management.

Pest Management Research and Development. Research aimed at ways of reducing pest damage through the use of integrated, environmentally acceptable control methods includes work in plant disease, insect pest and weed management, and in pesticide analysis and methods development.

Water/Wastewater Research and Development. Programs examine the environmental chemistry of wastewater, water quality improvement processes and aquatic toxicology.

Environmental Toxicology. Research focuses on the effects of agents which are introduced into the environment and includes field and laboratory studies in inhalation toxicology, toxicology of pesticides, ecological toxicology, and the effects of environmental sulphur.

Living Natural Resources. Research deals with the effects of physical, chemical and biological environmental changes on grasslands, forests, aquatic species, birds and wild mammals.

Waste Management Research and Development. Focus is on physical, chemical and biological processes which may be applied to waste management.

Land Resources Management Research and Development. Studies examine long-term effects of major uses on Alberta's land resources, with emphasis on reclamation of disturbed sites and technical solutions to land-use problems.

Alberta Environment, Research Management Division. Alberta Environment channels millions of research dollars each year into a variety of environmental research programs, many of which are co-funded with industry. Research funding and coordination within the department is the responsibility of the Research Management Division (RMD). The RMD divided its 1984/85 research budget of $3,154,000 between the Alberta Oil Sands Environmental Research Program (AOSERP) and the general Environmental Research Program.

Alberta Oil Sands Environmental Research Program (AOSERP). AOSERP started in 1975 as a 10-year project funded by the federal and provincial governments. Alberta Environment took over responsibility for the program in 1979.

AOSERP was created to fund and coordinate research related to the impact of petroleum mega-projects on the environment and people in the province's oil sands areas. It now concentrates on two main areas: environmental effects of acid forming emissions, and effects of industry development on quality and quantity of water resources.

Environmental Research Program. This program in 1984/85 comprised eight areas of priority research, including reclamation research (funded by $1,500,000 through the Alberta Heritage Savings Trust Fund), acid deposition, waste management, water resources, environmental contaminants, air quality and climatology, geotechnical, and risk assessment/environmental emergencies.

Alberta Environment Research Trust (AERT). The AERT is funded by a grant of $340,000 from RMD and also receives industry support. Established to fund research that may not otherwise receive support, the trust received more than $560,000 in 1983 from public and private sources.

Reclamation Research Program. Established in the late 1970s this 10-year government/industry program is aimed at identifying the most efficient methods for reclamation of large-scale surface disturbances. This program is administered and managed by the inter-agency Reclamation Research Technical Advisory Committee (RRTAC), which reports to the Alberta Environment/Energy and Natural Resources Land Conservation and Reclamation Council.

By 1984, RRTAC had suported 46 projects in three program areas: plains coal, where research is directed at reconstruction of agricultural soils and changes in groundwater related to strip mining; oil sands, which involves studies of soil reconstruction and reforestation on tailings sand; and mountains and foothills coal, where investigations include soil reconstruction for forestry and wildlife habitat, and hydrologic studies.

Alberta Research Council (ARC). ARC performs a substantial amount of environmental research for

RRTAC and other government departments and agencies. Through its Natural Resources Research Program, it conducts work in geology, soils, groundwater and atmospheric sciences.

ARC's environmental geology research has two components: surficial geology and quaternary stratigraphy of the glacial sediments of Alberta; and reclamation, particularly related to coal mining.

ARC environmental research projects jointly funded with Alberta Environment include: a major study to evaluate the potential environmental impacts of in-situ processes in the Cold Lake oil sands; a study to obtain airborne measurements of emissions from oil sands processing plants; and development of a framework for predicting the impact of coal mining on local and regional water resources and the probability of long-term success in land reclamation.

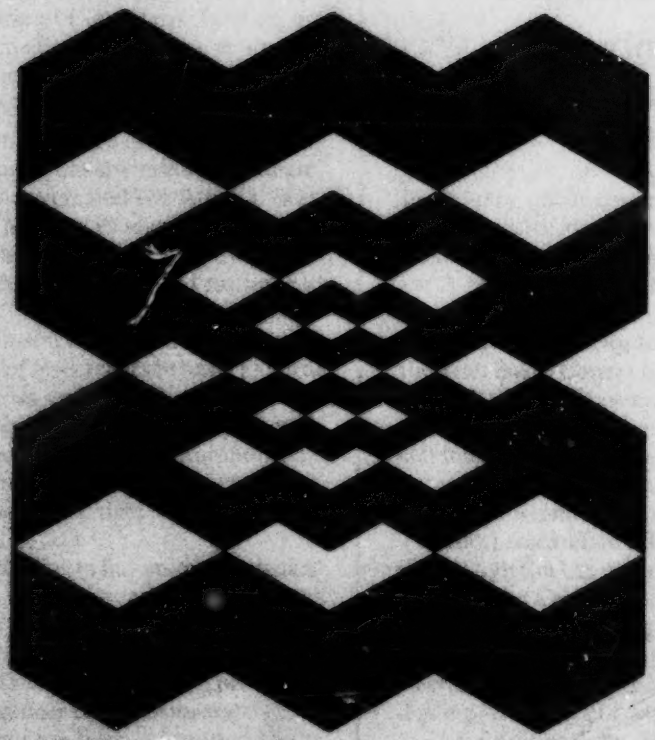
PUBLIC/PRIVATE EFFORTS

Alberta Government/Industry Acid Deposition Research Program (AGIADRP). This program was initiated in 1983 to study the occurrence and effect of acid deposition in Alberta resulting from airborne pollution, and to recommend courses of action. It is a seven-year, $8-million program funded and participated in equally by the Canadian Petroleum Association, other industry groups, and the provincial government.

The most comprehensive multidisciplinary effort on acid deposition ever undertaken in Alberta, this program will commission studies on oxides of sulphur and nitrogen and their effects on the terrestrial environment. Research will be divided into two main areas: biophysical investigations of pollutant sources and their effects on vegetation, soils and water; and medical research into the effects of pollutant sources on human health. The program will advance worldwide scientific knowledge in these areas.

Funding and technical input from the provincial government perspective to AGIADRP is provided by Alberta Environment's Research Management Division. The division also funds a departmental program of acid deposition research in the oil sands area which is supplementary and complementary to AGIADRP.

Medicine



Medicine

A strong commitment to medical research at both the basic and applied levels is earning Alberta an international reputation for excellence in many areas, and is attracting top medical researchers to the province.

Medical research in Alberta is so diverse that only a brief overview can be presented here. Almost all medical reseach is performed at the province's universities, in conjunction with major hospitals. These institutions also provide the resources used by private industry in applying medical knowledge to new products and technology.

Funding Medical Research

Because important breakthroughs in medicine do not happen overnight, sources of long-term funding are particularly crucial to medical research. The amount of support given to medical research in Alberta is significant in this respect.

Alberta Government. In 1979, at a time when funding for medical research was dwindling elsewhere, the Alberta government created the Alberta Heritage Foundation for Medical Research (AHFMR), backed by a $300-million endowment fund, to ensure that medical research in Alberta would continue to prosper.

The AHFMR has since received international praise for its support of researchers in basic medical and clinical sciences, as well as in chemistry, zoology, genetics, microbiology and biomedical engineering. The Foundation is relatively autonomous, operating independently of political or economic changes to give researchers time and security in pursuing their work.

Cancer research in Alberta has enjoyed substantial support ($3-3.5 million per year) since 1977 from the Alberta Heritage Savings Trust Fund - Applied Cancer Research Program. This program is administered by the Alberta Cancer Board as part of its mandate to provide cancer care in Alberta.

Another $10 million has been committed by the Alberta government to a seven-year Occupational Health and Safety, Research and Education Program. The Alberta Heritage Foundation for Nursing Research, with a $1-million budget over five years, provided $200,000 for research on care-oriented aspects of nursing in 1983/84, its first year of operation. Other government departments also provide funding for research in health and health care.

Federal Government. The National Research Council and the Natural Sciences and Engineering Research Council of Canada both fund medical research in Alberta, but the major contributor is the Medical Research Council (MRC) of Canada. In the 1983/84 fiscal year, Alberta received $10 million of the MRC's $137.3 million research expenditure.

Other. The contribution to medical research made by the many charitable foundations and societies in Alberta and Canada is significant. For example, the Canadian Heart Foundation is a major funder of heart research in Canada, and its provincial body, the Alberta Heart Foundation, spent close to $1.5 million on research in 1984.

Institutional Research

CANCER

In Calgary, most cancer research is conducted by a consortium of the University of Calgary Faculty of Medicine, and Tom Baker Cancer Centre (a facility of the Alberta Cancer Board) and the Foothills Hospital.

An Oncology Research Group within the University's Medical Faculty acts as the basic research arm of the Tom Baker Cancer Centre. This multi-disciplinary group has major research interests in chemotherapy and immunotherapy, genetic engineering, and cell-to-cell interactions as they relate to metastasis. A major automated cell analysis and sorting facility for research and diagnosis has also been established.

Cancer research in Edmonton is conducted primarily through the University of Alberta Faculty of Medicine and the Cross Cancer Institute, and includes two of the largest programs funded through the Alberta Heritage Savings Trust Fund — Applied Cancer Research Program: one in radiobiology and the second dealing with Nuclear Magnetic Resonance (NMR).

The Radiobiology Program at the Cross Cancer Institute enjoys an international reputation for its work in radiosensitizers and protectors. The program studies radiation mechanisms related to cells and tissues and the biology of solid tumors.

The NMR project is funded jointly through the Heritage Savings Trust Fund - Applied Cancer Research Program and the AHFMR. It includes a large NMR facility capable of performing NMR work

in-vivo and an interdisciplinary research group of University and Cross Cancer Institute specialists in physics, surgery, nuclear medicine, biochemistry, tumor biology and engineering. Unlike other NMR facilities in Canada, this project is research-oriented, aimed at developing and exploiting NMR's application to medicine in imaging and localized spectroscopy.

A new program, in molecular genetics and carcinogenesis (oncogenes), was started at the Cross Cancer Institute in July 1985 with a major establishment grant from the Alberta Heritage Foundation for Medical Research. A senior Canadian scientist of international repute was recruited to lead the program.

The Department of Immunology in the University's Faculty of Medicine is involved in research and development into cancer diagnosis, detection and therapy. A new technology developed in the department based on monoclonal antibody technology could be used commercially very soon to detect cancer antigens in the blood of cancer patients.

At the Hormone Receptor Laboratory in Edmonton, cancer research is aimed at determining concentrations of estrogen receptor in human mammary tumor samples; and at the McEachern Cancer Centre, which receives major funding from the National Cancer Institute, researchers are examining the use of chemical compounds for treating cancer.

A provincial Epidemiology and Cancer Registry has been established to help in examining the demographics and potential causes of cancer in Alberta.

HEART

The University of Calgary's strong, interdisciplinary Cardiovascular Research Group focuses on tomography, arrhythmia, basic cardiac cell metabolism and heart mechanics.

In addition to projects looking at hypertension, sudden cardiac death, hemodynamics and electrophysiology, the Calgary group conducts forefront studies in pharmacology, echocardiography, nuclear medicine images, angioplasty and pacemaker technology. It is one of the few heart research groups in North America which cover the spectrum from laboratory studies of single heart cells to clinical research with cardiac patients.

At the University of Alberta, researchers are seeking answers to a wide range of heart-related questions. Work at the University has included the first use in Canada of a two-dimensional echo imaging unit with nitro-glycerine for treating and diagnosing heart disease; research into resistance to blood flow in the body's arteries; and examination of physical fitness and lifestyle as factors in heart attacks and heart disease.

BIOCHEMISTRY AND GENETICS

Basic and applied research in the structure, growth and development of cells crosses disciplinary borders at the University of Alberta and the University of Calgary.

The single largest research grant to the University of Alberta — covering more than $6 million over a five-year period — was awarded by the Medical Research Council to the University's Protein Group in 1984. Located in the Biochemistry Department, this group has become known for world-class research into the structure and function of enzymes, muscle proteins and protein-nucleic acid interactions, all of which are fundamental to life.

Other projects underway in the University of Alberta's Faculty of Science include a number of studies of recombinant DNA technology aimed at revealing information about gene transmission, gene expression, and reaction of DNA with potential cancer-causing agents. Work is also being done on the synthesis of specific oligosaccharides which have been bound to solid supports and used for blood typing; isolation of antibodies and extracorporeal removal of antibodies from human blood; and application of NMR techniques to intact red blood cells and other cellular systems. The Faculty is also involved in projects on the mathematical modelling of blood flow; the development of methods to significantly improve the production of existing and new antibiotics; hormonal regulation; human red blood cell disorders; and the biochemical basis of mutation.

In Calgary, the new Cell Regulation Group at the University has attracted a "critical mass" of scientific brain power — from pharmacologists and protein chemists to physiologists — to examine how living cells regulate what they do, both in metabolic and physiological functions. There is a particularly strong research interest in such messengers as cyclic AMP and calcium, and in such secondary messengers as the protein calmodulin.

The University has one of the largest concentrations of expertise in genetic engineering and biotechnology in Canada: the multi-disciplinary Growth and Development Research Group. Research interests of the group include genetic expression, fetal well-being, genetic diagnosis, and infertility. A major sub-group, the Southern Alberta Hereditary Diseases Program, features work on cytogenetic inborn errors and includes the first molecular diagnosis unit in Canada.

IMMUNOLOGY

Understanding the human immune system is the key to fighting a variety of diseases. A number of researchers

in Calgary and Edmonton are involved in studies along these lines.

In addition to its work on cancer diagnosis and detection, the Department of Immunology in the University of Alberta's Faculty of Medicine is involved in research related to bone marrow transplantation which has high potential for commercial applications. The group also carries out studies in basic immunology.

The University of Calgary's Immunology Research Group concentrates on understanding mechanisms of immune regulation. Clinical and basic researchers collaborate on projects emphasizing cell-mediated immunity and autoimmunal disease. The group also contains an Arthritis Disease Unit.

Through the University's Infectious Diseases Research Group, work is being conducted on the relationship between viruses and cells, and on antibiotic action, passive immunity and molecular virology.

At the University of Alberta, a team of researchers has gained international recognition by observing a relationship between the immune system and multiple sclerosis (MS) which suggests that MS may not be only a disease of the central nervous system. A research team in the University's Department of Biochemistry is studying ways to manipulate the immune system and synthesize its components, particularly lymphokines, for use in controlling both inactive and overly active immune systems. Headway is also being made by university researchers in developing a new vaccine against the herpes simplex virus.

NEUROSCIENCE

The Neurosciences Research Group at the University of Calgary has strengths in neural cell physiology, temperature regulation and visual physiology. The Group is associated with the Lion's Sight Centre.

A small neurophysiological group at the University of Alberta is involved in projects that range from basic research to rehabilitative medicine. Members of the Faculty of Pharmacy and Pharmaceutical Sciences are active in neurochemistry research, studying links between drugs and behavior from the biochemical to the clinical level. The Faculty is also involved jointly with the Department of Psychiatry in projects looking at some of the neuro-active aimings in the brain and in the establishment of a new Mental Health Research Unit, supported with five years of funding from Alberta Social Services and Community Health. The Unit will focus on depression, hyperactivity and Gilles de la Tourette's Syndrome.

LASER

The only research team in Canada which specializes in extending the use of laser technology inside the body is located at the University of Alberta. The group is attempting to minimize or eliminate the need for conventional surgery by using lasers to remove tumors from the deep recesses of the brain, lung and bladder. The team is breaking new ground by using laser to diagnose and arrest early stages of certain cancers. It is also pioneering treatment of certain kinds of bladder cancer and tumors on the brain and spinal cord.

PHARMACY

In addition to its work in neurochemistry, the University of Alberta Faculty of Pharmacy and Pharmaceutical Sciences conducts a broad range of research in other areas — much of it oriented towards commercial application and funded from industry sources.

As a result of its work in synthetic chemistry, the Faculty has made and patented a number of compounds. Private sector funding, mainly from Japan, is supporting research on penicillin-like antibodies. The Faculty is also researching cyclosporins, drugs that fight rejection from transplants.

In nuclear pharmacy, the faculty is active in both radiochemistry and radiopharmacy. Projects include research into the use of radionuclides to study chemical reactions and to tag drugs used within the body, as well as work on producing radioactive drugs that can be administered to patients. This research has produced a spin-off, the Edmonton Radiopharmaceutical Centre, which supplies radiopharmaceuticals to Edmonton hospitals.

The Faculty has a small nuclear reactor, one of only a handful in Canadian universities, which is used by a number of departments and some companies for pharmaceutical, medical, geological and agricultural research.

Drug and product development are important research areas within the Faculty. Work on phospho lipids is aimed at producing a drug which can be released in very predictable levels in the body, while research on pharmacokinetics, which will assist in hospital monitoring of a drug, has sparked a good deal of industry interest. Basic research is also being performed on the physiology and pharmacology of the pulmonary system as it relates to such phenomena as allergic reactions.

GASTRO-INTESTINAL RESEARCH

The Gastro-Intestinal Research Group at the University of Calgary conducts major research related to gastro-secretions, gut homeostasis and nutrition. An outstanding Intestinal Disease Research Unit, funded by the Canadian Foundation for Ileitis and Colitis, is part of the group.

OTHER INSTITUTIONAL RESEARCH

The University of Alberta and the University of Calgary conduct significant research into diabetes: the former through its Muttart Diabetes and Metabolic Research Unit and the latter through the new McFarlane Diabetes Research Unit of its Endocrine Research Group. The Group has major strengths in neuro-endocrinology and hormone/pharmocological receptors.

Both universities have ongoing work in biomechanics, health care, behavioral sciences and other areas which integrate basic and applied research. The University of Alberta has established the Centre for Gerontology, a multidisciplinary group dealing with numerous topics relating to the aging process.

At the University of Calgary, a group in the Biology Department is working on projects related to cystic fibrosis involving bacterial surface polysaccharides and the effect of antibiotics. Other work in biochemistry concerns studies of metal ion toxicology, immunology, lectins, and cell surface receptors. In the Chemistry Department there is research supported by the Alberta Heritage Foundation for Medical Research on drug action, synthesis of new drugs, and processing of pituitary hormones.

The University of Calgary Faculty of Medicine has Canada's highest concentration of reproductive physiologists, who work within the Growth and Development Research Group. The Group is one of the main reasons for the location of a world-scale livestock seed industry in Alberta. It also accounts for the highest concentration in Canada of animal reproductive physiology and genetics research with accompanying technology transfer through to the agriculture industry.

Examples of Other Public and Private Sector Research

BIO LOGICALS inc./Alberta Research Council. A joint venture genetic engineering project between BIO LOGICALS and ARC began in 1982. The multi-million-dollar effort is aimed at developing pharmaceuticals and specialty chemicals through genetic engineering. A computer program has been developed for DNA sequence analysis and researchers have successfully introduced synthetic DNA into bacterial systems.

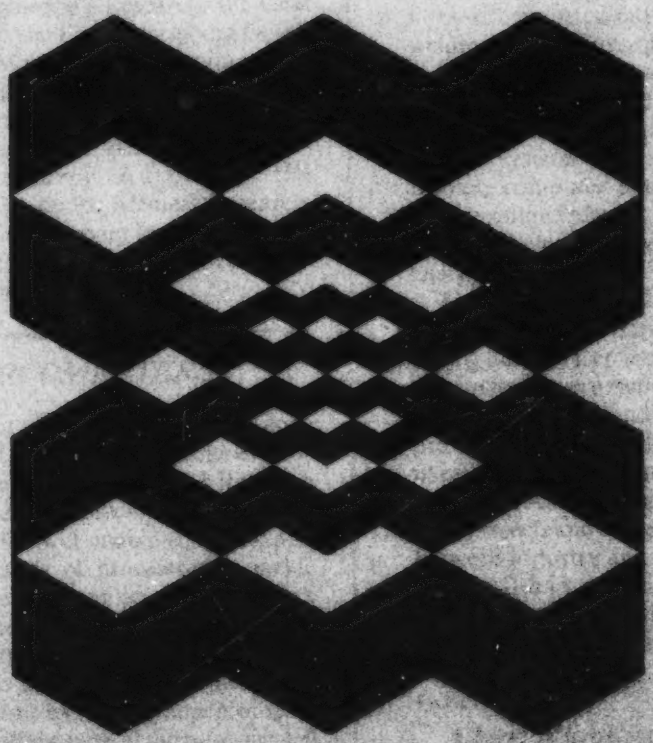
ARC is also investigating the process development required to bring a genetically engineered product into production. A pilot plant will make full use of computerized process control technologies, and another project will concentrate on developing process equipment which could be manufactured in Alberta.

Chembiomed Ltd. A University of Alberta-owned company, in which the Alberta government has purchased $2.9 million in preferred shares, Chembiomed was formed to manufacture commercial chemical products for medical use.

The company manufactures blood-typing reagents using cloned cells from mice and markets blood purifiers which lessen the chances of reactions to organ and bone marrow transplants. In 1984, it contracted with an American company to market a blood reagent for blood typing.

Chembiomed is also working on commercial products based on a University of Alberta professor's discovery of a way to produce synthetic complex sugars, or polysaccharides. A polysaccharide is believed to be the active ingredient in red-ant venom long used by natives in the Amazon for arthritis. Chembiomed's work could lead to a no-side-effects product that would provide long-term relief from arthritic pain.

Some Other Selected Forefront Technologies



Some Other Selected Forefront Technologies

Research, development and commercialization of forefront technologies are playing an increasingly important role in Alberta's economy.

The province's electronics industry, in particular, has grown rapidly in recent years. Much of the research and development in this area is related to product generation, which accounts for an expenditure of about $250 million a year and which has resulted in breakthroughs in non-electronics fields as well.

The infrastructure needed by this industry to develop in Alberta is provided by industry, the universities, and the provincial and federal governments through such facilities as the Alberta Microelectronics Centre, the Centre for Frontier Engineering Research, the Coal Mining Research Centre, the Food Processing Development Centre, the Alberta Telecommunications Research Centre, and the Electronics Test Centre. Special funding and venture capital are provided by Alberta Research Council, the Alberta Oil Sands Technology and Research Authority, the Alberta Heritage Foundation for Medical Research, Vencap Equities, Alta-Can Telecom Inc., and others.

The following is a sampling of the forefront technology resources available in Alberta.

THE SUPERCOMPUTERS

An important component of Alberta's high technology environment is a project to build what promises to be the world's most powerful computer. Myrias Research Corporation of Edmonton is developing a software control mechanism which will enable scientists and engineers to use thousands of processors to tackle independent parts of the same application in parallel. This fundamental advance in computer science will make possible the solution of design and modelling problems which are too large or too complex to be treated in a reasonable time by existing supercomputers. The resulting $12-million general purpose parallel computer system will run faster on a wider range of applications than any conventional supercomputer.

The computing capability available to emerging high-tech companies and university researchers received an unprecedented boost in 1984, when the University of Calgary acquired Canada's third supercomputer — the first at a Canadian university. Computing science students from all Alberta universities will have access to the powerful Cyber 205, as will Alberta companies developing new software and electronics products.

Acquisition of the Cyber 205 was made possible through a $10-million pre-purchase of computing time by the Government of Alberta and by a $15-million donation from Control Data Canada Ltd. of Mississauga, Ontario.

UNIVERSITIES

University of Alberta. The Department of Electrical Engineering at the University of Alberta has strong links with industry, particularly in the fields of laser welding and cutting, optical fibre communications, medical uses of lasers and electromagnetic heating of tar sands. Research groups in the Department work in electromagnetics, biomedical engineering, control systems and instrumentation, microelectronics, computer engineering, communications, high-vacuum technology, microwave power, lasers, plasmas, power systems, radio astronomy and solar energy.

The Department houses the Alberta Microelectronics Centre and is involved, along with the Computing Science Department, in a major cooperative university/government undertaking to establish microchip design and fabrication facilities in the province within the Microelectronics Centre. In parallel with the Centre, the Department has established the Alberta Laser Institute, which sponsors laser projects and acts as an interfacing organization between industry and the University. The Department is also involved in the new Alberta Telecommunications Research Centre, which is jointly funded by the University of Alberta and Bell Northern Research, with support from the Alberta Government.

Alberta Microelectronics Centre. A non-profit corporation, this centre assists in the transfer of technology between industry and the University through contracts and courses in such areas as CAD/CAM, robotics, programmable controllers, sensors, semi-custom integrated circuits and real-time software.

Laboratories and equipment of the Department of Electrical Engineering are made available

to industry through the Centre. These include a $2.7-million CAD/CAM system; an optical fabrication shop containing a Microsurface Lathe — one of about 10 in the world — for fabricating precision equipment; and a Gate Array Microchip Customizing Facility for building prototypes.

In 1985, the Centre received a $13-million, three-year operating grant from the Alberta government to manage microchip design and fabrication facilities at the Universities of Calgary and Edmonton respectively. The facilities will provide training for future engineers and will provide microchip design and fabrication assistance to industry.

The University's rapidly-growing Computing Science Department does research into data base management, computer graphics, robotics, software engineering, operating systems, user interface design, artificial intelligence, computer architecture, microcomputers and computer program testing.

The University's nuclear physicists perform basic research related to the structure of the nucleus and the interaction of nuclear and subnuclear particles. The University is a partner in the TRIUMF meson factory (one of only three such accelerators in the world) located at the University of British Columbia. Collaborative research with physicists in France and the United States is also underway.

Other physics projects with potential for applications include experiments with radiation used in the treatment of tumors, medical diagnosis and nuclear medicine; studies of methods to improve hydrocarbon extraction; and atmospheric studies on aurora that are helping to reveal their effects on communication and electric power lines.

University of Calgary. A large federal government grant shared by the University of Alberta and the University of Calgary is funding research and development of Very Large Scale Integration (VLSI) systems. Calgary's Departments of Computing Science and Electrical Engineering are working together on VLSI design and software, while the University of Alberta is concentrating on fabrication. The two departments are also involved in a cooperative undertaking with their counterparts at the University of Alberta, Alberta Research Council, and the Alberta Microelectronics Centre to establish microchip design and fabrication facilities in Alberta. The design centre is to be located at the University of Calgary, and the fabrication centre at Edmonton.

Calgary's Computing Science Department is working on a major software design project known as JADE. Funded by NSERC, the project is aimed at building an environment which supports the design, construction and testing of distributed computer systems. Other departmental research is assisted by the largest university MULTICS installation in the world and covers most areas of modern computer science.

Other significant computer research projects include development of 3-D color graphics animation, a multi-media adaptive work station for the disabled, development of small expert systems, and work on concurrent execution of logic programs.

Developments in biotechnology include extensive studies of immobilized cell bioreactors and their use in the production of antibiotics and antibodies. The Biology Department is actively engaged in research in recombinant DNA technology and in a variety of fermentation relation projects.

In physics, satellite image processing technology is the major focal point for a research team with substantial contract support.

The Department of Electrical Engineering has a substantial group specializing in communications, with particular interest in fibre optics and the use of computers in communication systems. It also has expertise in signal processing and image modelling techniques which have applications in medical technology. Other research includes development of downhole instrumentation for the oil industry, which has resulted in successful commercial products; power system control; power electronics; and computer aided design and manufacture.

The Department of Mechanical Engineering is working on computer aided design and manufacture with the aid of a substantial design and graphics facility based on a Harris 800B computer and a Matsuura computer-controlled machining centre.

Survey engineering research at the University includes computerization of survey work and image processing for analysis of Landsat data. A Statistics Consulting Laboratory in the Mathematics Department, which contracts with industry and government, has helped in development of 3-D seismic mapping.

TELECOMMUNICATIONS/ COMMUNICATIONS

Bell-Northern Research Ltd. (BNR). Canada's largest industrial research and development organization, BNR has a major facility in Edmonton's Research and Development Park. Owned by Northern Telecom Limited and Bell Canada, BNR provides the former with research and development support for its western manufacturing plants and is the Canadian leader in fibre optics.

At BNR's Edmonton laboratory, development of fibre optics transmission products is a key priority. Research focuses on high-capacity fibre optics transmission for long-haul telecommunication of voice, data and video; fibre optics transmission between offices in a metropolitan area; and outside

plant equipment to support fibre optic installations. The laboratory is also the design house for the Vantage 48 key telephone system. BNR also houses the new Alberta Telecommuncations Research Centre.

Alberta Telecommunications Research Centre. Opened in the spring of 1985, this centre is jointly funded by Bell Northern Research, the University of Alberta and the Government of Alberta. Research will focus on two major areas: fibre optics to aid in electronic communication, and computer-aided design of microelectronic products and services.

NovAtel Communications Ltd. Jointly owned by NOVA, AN ALBERTA CORPORATION and Alberta Government Telephones, NovAtel is a North American leader in the research, development, manufacturing, and marketing of advanced cellular telecommunications systems and terminals.

In 1983, NovAtel put North America's first cellular system and the first decentralized system in the world — the AURORA — into commercial operation in Alberta. Through state-of-the-art computer-based control, the AURORA routes all voice traffic through local exchanges, using the existing land network and eliminating the need for an expensive "central switch", while reducing the operational expense of "backhauling" calls over miles of dedicated circuits.

NovAtel also manufactures the AURORA family of mobile radio telephones. The company's cellular products utilize Very Large Scale Integration (VLSI) technology, whereby tens of thousands of electronic components are integrated on a single silicon chip. With the aid of sophisticated Computer Aided Design (CAD) tools, the company is developing custom integrated circuit designs utilizing Complementary Metal Oxide Semiconductor (CMOS) technology.

Advanced Technology at NovAtel is involved in applied research of novel digital communication networks and terminal products. Included is work on: use of Infra-Red light for high-speed, free-space transmission; voice recognition for control over the functions of automatic systems through use of the spoken word; digital switching and transmission systems, including network architectures and protocols; digital radio transmission, including advanced modulation and coding schemes; radio propagation within building structures; and alternatives for high volume, low cost, high reliability packaging.

Harding Instruments Co. Ltd. An Edmonton-based electronic consultation, design and manufacturing company, Harding Instruments is involved in research and development of new products for the business telephone market. The company has begun North American marketing of a microprocessor-based, expandable two-line key system which overcomes long-standing American patents. Research is also being done on data transmission products. Harding has expertise in process control/process measurement; machine control; bio-medical electronics; and application processing of CSA and UL certifications.

Idacom Electronics Ltd. Another Edmonton-based firm, Idacom, has a research and development budget of about $4 million a year, with work focused on data communications test equipment. Idacom's major product is the IDA-XP Protocol Analyzer, which is designed to monitor, emulate and intercept or modify serial data. It may also be used, among other applications, as a development aid in simulation.

Tundra Technical Industries Limited. Tundra, headquartered in Edmonton, is involved in research, development and modification of data and voice communications systems to meet the specialized needs of the oil and gas exploration industry. These include HF/SSB radio communication systems; aircraft communication and navigational packages; VHF repeaters and unattended mountain top repeater systems; aircraft and marine nondirectional beacon systems; transportable communication and environmental monitoring centres; AM systems; trail radio systems; and satellite earth stations.

PROCESS CONTROL/ INSTRUMENTATION

Cov-Can Control Systems Ltd. Headquartered in Calgary, Cov-Can specializes in the development of applications software for pipeline control, primarily for the oil and gas industry. This includes process modelling to help determine how a system should be operating, identifying anomalies and developing short- and long-term solutions. Cov-Can software can also be used to develop process forecasts, determine market conditions and sources of supply, and obtain constraint information.

Datek Industries Limited. Datek supports the Alberta resource industry through design, manufacture and programming of microcomputer systems for data acquisition, monitoring and control, and telemetry. Much of this Edmonton company's current research is directed at computer-based gas flow and oil flow measurement technology. It also has a comprehensive development program in remote control and data acquisition instrumentation.

D.B. Robinson & Associates Ltd. Located in Edmonton's Research and Development Park, this research-intensive group serves the fluid property

needs of oil and gas-related industries internationally. Activities include development and marketing of computer software for predicting the properties and behavior of natural gas, oil and related materials; development of technology to experimentally measure the behavior of gases and liquids encountered in oil and gas production and processing; and design, manufacture and sale of specialized equipment, such as high pressure pumps, cells and related devices for use in operating experimental laboratories.

ITT Barton Instruments. A division of ITT Industries of Canada Ltd., this Calgary-based firm specializes in the design, manufacture and servicing of process instrumentation which it markets worldwide. The company specializes in instrumentation for flow and level measurement where the client requires highly reliable measurement under harsh environmental conditions. The majority of the company's research and development is performed by its own application engineers or is subcontracted to outside firms which have a particular expertise in a specific field.

Nowsco Well Service Ltd. A Calgary-based well service company specializing in cementing, acidizing and fracturing. Nowsco operates throughout Canada, Europe, Southeast Asia and the northeastern United States. Its Special Services Division has been responsible for the development of instrumentation suited to the "oil patch" environment, where vibration, temperature extremes and high humidity prevail.

Sherrex Systems Ltd. Sherrex Systems of Edmonton designs and manufactures high technology products used by the industrial sector for control and monitoring of processes, buildings and computers. Sherrex also has strength in fibre optic communication products and industrial fibre optic systems. The company's major research thrust is on development of microprocessor-based remote monitoring and control units.

SUPERVISORY CONTROL

ALBION Microelectronics Corporation. ALBION is a Canadian-owned, Calgary-based company specializing in the research, development, manufacture and marketing of microelectronic products. The company is currently introducing its A.C.C.S. (ALBION Configurable Control System), the "shell" from which a Supervisory Distributed Network can be applied to such diverse industries as oil and gas, transportation, water management, building management, and commodity packing and dispensing. ALBION provides the necessary supervisory software and ALBION Intelligent Controllers to adapt the A.C.C.S. to a particular application.

The company has also developed the A.M.M.S. (ALBION Maintenance Management System), which is currently being used by members of the aircraft industry to obtain both preventive and predictive maintenance information. Other applications are currently under development.

Sentrol Systems Ltd. One of the largest Canadian suppliers of computer-based Supervisory Control and Data Acquisition (SCADA) systems to pipelines, Sentrol concentrates product research and development at its Calgary facilities on the development of hardware, software and electronic products relating to the oil, gas and water pipeline industries.

Westronic Systems Ltd. Westronic, based in Calgary, specializes in supervisory control and data acquisition (SCADA) systems. Major focus is on development of remote control and data acquisition products for the oil and gas, telecommunications and power industries, particularly micro-computer-based systems for energy management and control. Westronic designed and developed the Wesdac line of software and hardware, one of the products it markets in Canada, the United States and overseas.

Willowglen Systems Ltd. Another Canadian leader in the development of SCADA systems, Calgary-based Willowglen specializes in oil and gas field automation, electrical distribution automation and water treatment and distribution automation. Willowglen conducts about 90 per cent of its business outside of Canada, primarily in the United States and Southeast Asia, and commits approximately 10 per cent of its annual revenues to research and development of its microcomputer-based product lines.

AGRICULTURE

Baker Engineering Enterprises Ltd. This Edmonton-based firm designs and manufactures electronic products for the agriculture industry including livestock control products, function monitors for farm machinery, custom-designed electronic controls for grain handling and processing plants, and flow meters for use on mobile equipment. Research and development emphasis is on new technologies for flow measurement and for monitoring and control of air seeders.

L-tronic Industries. Headquartered in Linden, L-tronic designs, manufactures and supplies electronic control monitoring devices for use in the swine, poultry and dairy industries. In 1984, with assistance from the Alberta government, the company undertook a project involving the design and development of better electronic environmental controls for agricultural complexes, such as poultry

and swine houses. The company is also involved in research and development of agricultural alarm systems.

Traders Tec-Systems Controls Ltd. Traders Tec-Systems of Bowden specializes in the automation of systems used by the agriculture industry. The company's major research and development thrust is related to its production of custom control panels for grain handling, seed cleaning, feed processing and materials handling systems.

CHEMICAL

Palco Electronic Manufacturing & Supply Ltd. This Calgary company specializes in telecommunications products and services for telephone companies in Western Canada. Current research is aimed at development of a chemical process for refurbishing the plastic components of telecommunications equipment. The process has potential for a number of other industrial applications. Palco is also involved in electronics research and development.

Raylo Chemicals Ltd. A subsidiary of Terochem Laboratories Ltd. of Edmonton, Raylo researches, develops and manufactures high technology specialty chemicals and polymers, most of which are exported for use outside of Canada. Raylo manufactures custom chemicals such as pharmaceutical intermediate and end products; specialty polymers, used primarily in the aerospace industry; pheromones, chemically produced insect attractants used by the agriculture industry for pest control; diagnostic dye products; and products for treating radioactive wastes. The company's contract research and manufacturing activities have included development of products for use in oil, gas and coal recovery; synthetic DNA replication and other biotechnological applications; pharmaceutical trials; and the rubber, agriculture and other industries.

ELECTRONIC DISPLAY

Digi Sign Co. Ltd. An Edmonton company which has produced diverse products, Digi Sign has a research and development program related to computer-controlled displays and electronic signs (message centres). A current emphasis is on development of low-energy, high-reliability electronic signs for traffic control.

ENVIRONMENT

INTERA Technologies Ltd. The only aviation-based environmental consultancy in Alberta, INTERA is a Calgary company that works closely with Alberta Research Council and other government agencies. INTERA developed the first synthetic aperture radar (SAR) system for commercial use. When installed in a turbo-prop aircraft, this system can be used to map sea ice conditions or terrain, as well as for oil spill tracking, collecting data for sea ice forecast models and in oceangraphic applications.

Under a $1.2-million project with ARC, a prototype of another INTERA concept — the Multi-Task Ice Data-Analysis System (MIDAS) — will be built and tested in the field. MIDAS will process the data received from the SAR system.

Wellsdale Research Limited. Wellsdale specializes in the design and manufacture of micro-processor based data acquisition systems for telemetry and/or on-site computer readable data recording. Applications include meteorological and hydrological measurements. The Edmonton-based company custom designs and prototypes electronic systems for cold weather applications, emphasizing high reliability and low power requirements. It also writes computer programs for remote control and data acquisition for several operating systems and in a variety of languages.

Wellsdale is the Canadian leader in the design, manufacture, and installation of arctic automated weather stations transmitting real time data via GOES (Geostationary Operational Environmental Satellite). An automated weather station on Ellef Ringnes Island, at 78 degrees north latitude, is powered by a Wellsdale photovoltaic system, the most northerly year-round operating photovoltaic installation in the world. Other Wellsdale photovoltaic installations include remote controlled pipeline block valve control systems in similarly isolated locations.

Western Research. This division of Bow Valley Resource Services Limited of Calgary offers a full range of specialized environmental and ecological services — from consulting, laboratory, and field precision testing services to development of process instrumentation — to the petrochemical, petroleum, pulp and paper and manufacturing industries.

The company is recognized internationally for its pioneering role in the development of sulphur species analysis and stack emission monitoring systems and is also involved in air quality monitoring, meteorology, acoustics and vibration, waste gas incinerators, telemetry and data acquisition systems, hydrocarbon analysis, U.V. process analyzers and Claus process research.

LASER

General Systems Research Ltd. Headquartered in Edmonton, General Systems specializes in research, development and manufacturing of CAD/CAM laser cutting and engraving systems. With funding assistance from the Alberta government, the company began a $6-million research and development program in 1983 that has resulted in the LaserCAM 400, the most advanced computer-automated laser cutting technology in the world.

This system is designed for continuous, high-speed precision cutting of computer-programmed patterns and designs on textiles and thin fibre materials. Five $2-million turnkey packages had been committed to the North American automotive industry by the end of 1984. Interest in the system has been expressed from industry around the world.

General Systems also operates three laser and chemistry laboratories in cooperation with Alberta Research Council and the University of Alberta.

MARINE

ARCTEC Canada Limited. A marine-oriented research company headquartered in Calgary, ARCTEC develops and tests ships and offshore structures for arctic and sub-arctic environments. See the company's listing under Ice Research in the Energy and Minerals section for a more detailed description of its research activities.

Caulfield Engineering. This Edmonton-based firm specializes in acquisition and processing of oceanographic data and the manufacture of related computer equipment. Its research and development efforts focus on the manufacture of specialty equipment to satisfy client requirements. The firm is also developing a standard line of electronic and computer equipment which can tolerate rugged use in oceanic or other environments.

OFFICE AUTOMATION

Keyword Office Technologies Ltd. Originally established as a service bureau, this Calgary company has become a world pioneer in the enhancement of existing office automation technologies to deliver total document mobility within different word processing environments. Jointly owned by private interests and TransAlta Resources Corp. (the investment arm of TransAlta Utilities), Keyword has developed the KEYWORD 7000, a combination hardware/software system which integrates incompatible word processing systems through high-fidelity document conversion.

Another Keyword product, COM.FILE, is the software packaging of a document to facilitate the translation and subsequent transmission between incompatible word processing systems in remote locations. This product is manufactured in Calgary for worldwide distribution. Keyword clients include many Canadian and United States government offices, as well as major corporations in North America.

POWER

Global Thermoelectric Power Systems Ltd. One of only three manufacturers of thermoelectric generators in the world, Global is headquartered in Bassano. The company provides remote power systems which burn fossil fuels, converting them into electrical power. Its research and development division is improving the practical application of thermoelectrics with focus on two main areas: refinement of the base technology, and system development design.

Rapid advancement is being made in liquid-fueled combustion techniques, ultra-sonic atomization, new burner systems and thermoelectric converter designs. In addition to marketing their existing commercial products, Global has been instrumental in developing several military and commercial prototypes, including a portable vehicle engine heater, a 0.5kw generator and a portable 0.1kw manpack power source. New commercial products include a hazardous area generator for locations where flammable gases or vapors are present in quantities sufficient to produce an explosion.

Global works on projects in conjunction with both the provincial and federal governments.

Invertor Technology. Headquartered near Calgary, this company is primarily involved in power conversion, doing contract research and development in areas ranging from radar to instrumentation for heavy oil recovery, as well as research and development related to its own products. These include radar instrusion alarms; single, dual and triple output power supply devices; battery chargers; DC converters; sine wave interruptable systems; sine wave invertors; and U.P.S. invertors. The company also manufactures printed circuit boards.

SURVEYING

EDO Canada Ltd. EDO Canada Ltd. develops, manufactures and markets high techology, precision electronic instruments and systems for the land survey and marine positioning and navigation markets. The company is a wholly owned subsidiary of the EDO Corporation of New York.

EDO Canada is a leader in the design and manufacture of dual channel satellite doppler receivers and in the development of sophisticated software programs to process acquired transit data. EDO also has expertise in the development of integrated marine navigation and data acquisition systems for scientific research and seismic ships.

Under a Canadian government development contract, EDO Canada has merged Defence Research Establishment Ottawa technologies with its own to produce MINS, a small fixed configuration integrated navigation system designed to meet the tactical requirements of Canada's naval force.

Itres Research Limited. A Calgary-based company, Itres specializes in developing survey-related and other applications for Charge Coupled Devices (CCDs) and optical discs. These applications, often developed for government or university clients, have included the use of CCDs for astronomical, pipeline and other surveys, as well as for X-ray measurement of stress. Work in both analog and digital optical discs is related primarily to the seismic industry.

Nortech Surveys (Canada) Inc. Nortech is a survey firm in Calgary which specializes in positioning and navigation techniques. The company is heavily involved in hardware and software development associated with its operations around the world.

Nortech worked with Ferranti of Scotland on development of the Ferranti Inertial Land Surveyor System; is involved in applied research and development of accurate marine and airborne navigation and land static positioning and surveying using satellite systems; has developed a laser/inertial profiling system; and is working on developing radio ranging systems for offshore, land-based and aircraft positioning.

In a $1.6-million joint venture with the ARC, Nortech is developing a computer-based navigational system which can be used on a small fixed-wing plane instead of on a helicopter. This will provide accuracy in aerial survey work, relying on satellite rather than ground signals for navigation.

TRANSPORTATION

Canadian Foremost Ltd. A world leader in the design and manufacture of all-terrain vehicles, this Calgary-based company also conducts a research and development effort of about $1 million annually. That research has resulted in the HEP pumping unit, an electronically-controlled hydraulic oilfield pumping unit which has already proved its effectiveness during tests on enhanced recovery projects and heavy oil wells in Alberta by producing at twice the rate of conventional units. The unit is also being tested in Venezuela, and Canadian Foremost is expecting a worldwide demand for the product.

EID Electronic Identification Systems Ltd. This Edmonton-based subsidiary of CN Rail manufactures automatic electronic identification systems for road and rail systems. EID is currently developing a computer-based transportation product for identifying moving vehicles. A commercial application is already in use on CN Rail, and research continues on other rail and highway applications.

OTHER

Alberta Research Council. ARC recently established an Advanced Technologies Department in Calgary which focuses on modern microelectronics and computer and automation technologies vital to industrial development and product innovation. Programs in this department interact with the Council's specialized information services and industrial assistance programs. A new $10 million Electronics Test Centre has been established in Edmonton to help promote research and development in the electronic products industry.

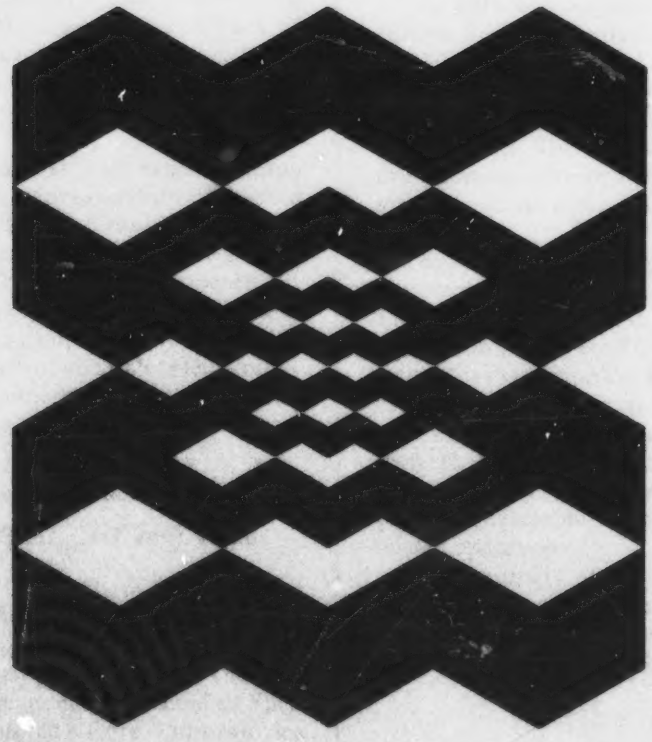
Canadian Centre for Learning Systems. A consortium of the University of Calgary, Mount Royal College, the Southern Alberta Institute of Technology, the Calgary Public and Separate School Boards, Honeywell Limited, Control Data Corporation, and Reid Chartwell, this not-for-profit Alberta company was established in Calgary in 1985 to perform research, development, evaluation, teaching and training in all areas of computer-assisted learning.

Named a centre of excellence by the federal government, which also provided close to $1 million towards its initial start-up, the Centre pursues activities that are national in scope. In addition to improving and providing consistency in the area of computer-assisted learning, the Centre aims to help stimulate development of learning systems, authoring tools, authoring languages and software.

The Centre will also work under contract to help develop Canadian software for specific needs and has been involved in the possibilities of developing courseware to support Canadian companies selling goods and services overseas. It is also prepared to work with companies in such areas as developing CAL (computer assisted learning) training programs.

This section is meant to provide a sampling of the cutting edge technologies developed and sold in Alberta. A significant number of other companies and agencies are similarly engaged.

Research and Development Parks



Research and Development Parks

Research and development activities require sophisticated support services and facilities. Both Calgary and Edmonton offer research and development parks with an array of such facilities to support industry growth.

Calgary

CALGARY RESEARCH AND DEVELOPMENT PARK

Northwest of the University of Calgary, the Calgary Research and Development Authority is developing the 432-hectare Calgary Research and Development Park, which will be the largest research park in Canada. The Park will provide an attractive environment for research facilities and for high technology manufacturing related to on-site research and development.

The Calgary Research and Development Authority is an autonomous non-profit organization established in 1981 as a joint initiative of the University of Calgary, the Calgary Chamber of Commerce and the City of Calgary. In 1985 the Authority opened the Calgary Advanced Technology Centre, which houses an incubator and innovation office to assist the launching and rapid growth of research or technology based enterprises; the southern Alberta laboratories and office of Alberta Research Council; and private sector research facilities.

UNIVERSITY RESEARCH PARK

Located adjacent to the University of Calgary is the 43-hectare University Research Park, the second largest industrial research park in Canada as measured in terms of facilities and employees on site. The park houses, among others, the research facilities of Shell Canada Resources Limited, Core Laboratories Canada Limited, The Institute of Sedimentary and Petroleum Geology, the Canadian Energy Research Institute, the Computer Modelling Group and the Petroleum Recovery Institute.

Edmonton

EDMONTON RESEARCH AND DEVELOPMENT PARK

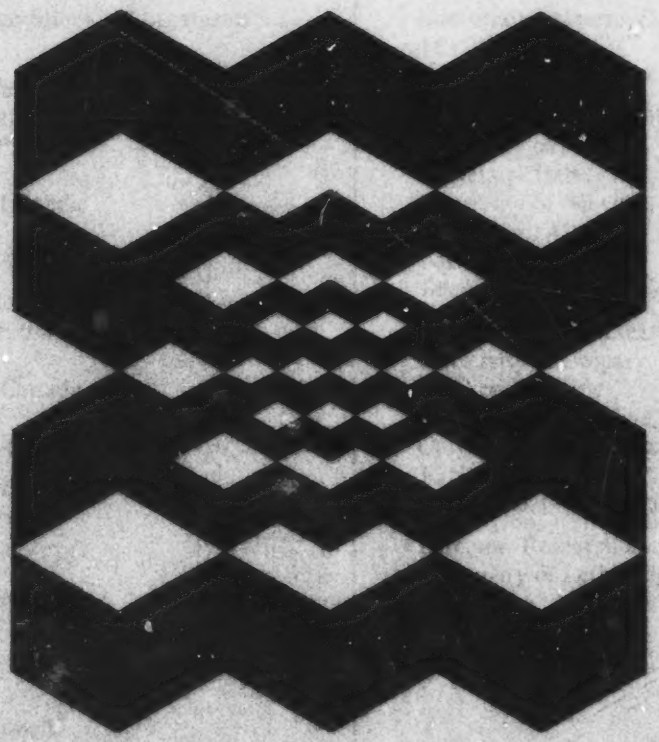
The 65-hectare first phase of the planned 260-hectare Edmonton Research and Development Park in South Edmonton was opened in 1980. This first phase, together with the adjacent 65-hectare Alberta Research Council site, comprise a research and technology-intensive community consisting of eight organizations employing over 700 scientists, engineers, technicians and support staff.

The Park and adjacent site house, in addition to Alberta Research Council, the Electronics Test Centre, Bell Northern Research, D.B. Robinson & Associates, Idacom Electronics Ltd., Robertson Photogrammetric Inc., Canadian Standards Association, and Lakewood Systems Ltd. The industries represented by these organizations include communications, oil and gas, remote sensing, precision measurement and product testing.

The Park is operated by an authority comprised of representatives from the City of Edmonton, the Province of Alberta, the University of Alberta, the Edmonton Chamber of Commerce and the advanced technology community. The Park is open to organizations which are research or technology-intensive, and which are committed to the performance of research and/or development at the Park, either as independent research centres or in conjunction with prototype development, manufacturing, servicing and related operations.

The University of Alberta and Alberta Research Council have extended assistance to Park tenants in the form of library facilities, meeting rooms, technical information services and laboratories.

Sources of Information



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Information in this publication was compiled from numerous sources by the Alberta Office of Science and Technology. For more information on science and technology in Alberta, or for assistance in reaching agencies or companies mentioned herein, please contact:

Office of Science and Technology
c/o Alberta Research Council
7th Floor, Terrace Plaza
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T6H 5R7
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Telex: 037-2147

More information on specific activities may be obtained by contacting the following organizations and agencies:

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Communications Branch
12th Floor, Sterling Place
9940 - 106 Street
Edmonton, Alberta, Canada
T5K 2P6
Telephone: (403) 427-0671

Alberta Heritage Foundation for Medical Resea
1200 Oxford Tower, Edmonton Centre
10235 - 101 Street
Edmonton, Alberta, Canada
T5J 3G1
Telephone: (403) 423-5727

Alberta Oil Sands Technology
and Research Authority
500 Highfield Place
10010 - 106 Street
Edmonton, Alberta, Canada
T5J 3L8
Telephone: (403) 427-7623
Telex: 037-3519

Alberta Research Council
7th Floor, Terrace Plaza
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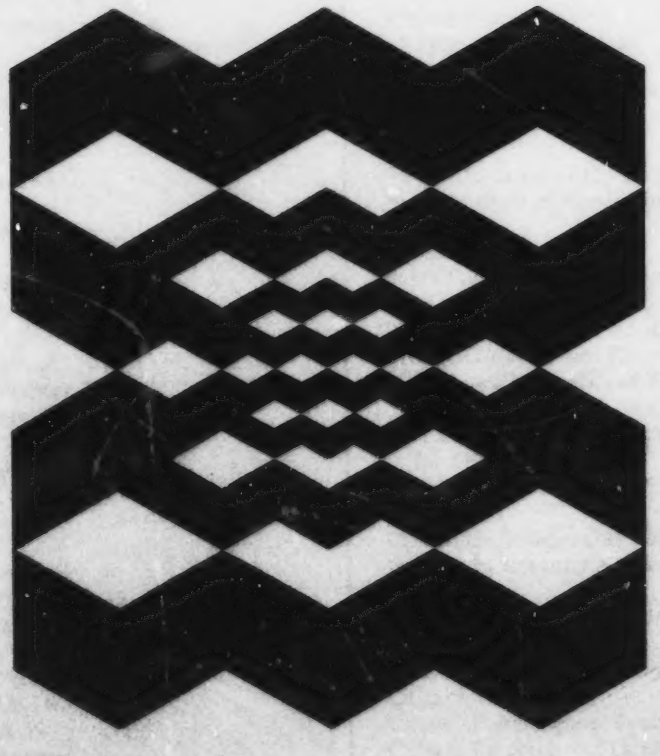

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